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H04L 12/28

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H4P PPA

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(54) Abstract Title
Programmable set-top box and home gateway

(57) Disclosed is a set-top box which interfaces with a plurality of household appliances such as one or more televisions, a VCR, DVD or MP3 player, or other audio equipment. The set-top box could therefore be said to be a home gateway. The set-top box contains one or more programmable logic blocks which allow the box to be upgraded or reconfigured by downloading to the box a new operating system or other software. Alternatively, the software or firmware for upgrading may be transferred on an interchangeable memory means such as and optical disc. The set-top box may be connected to the internet.

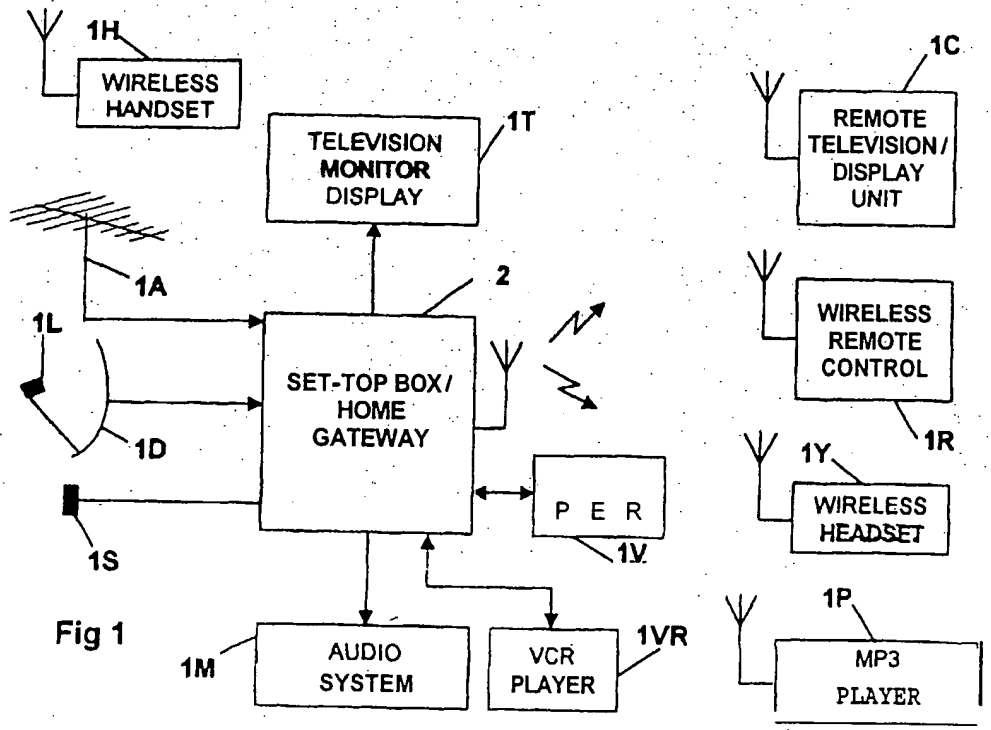


Fig 1

GB 2 381 709 A

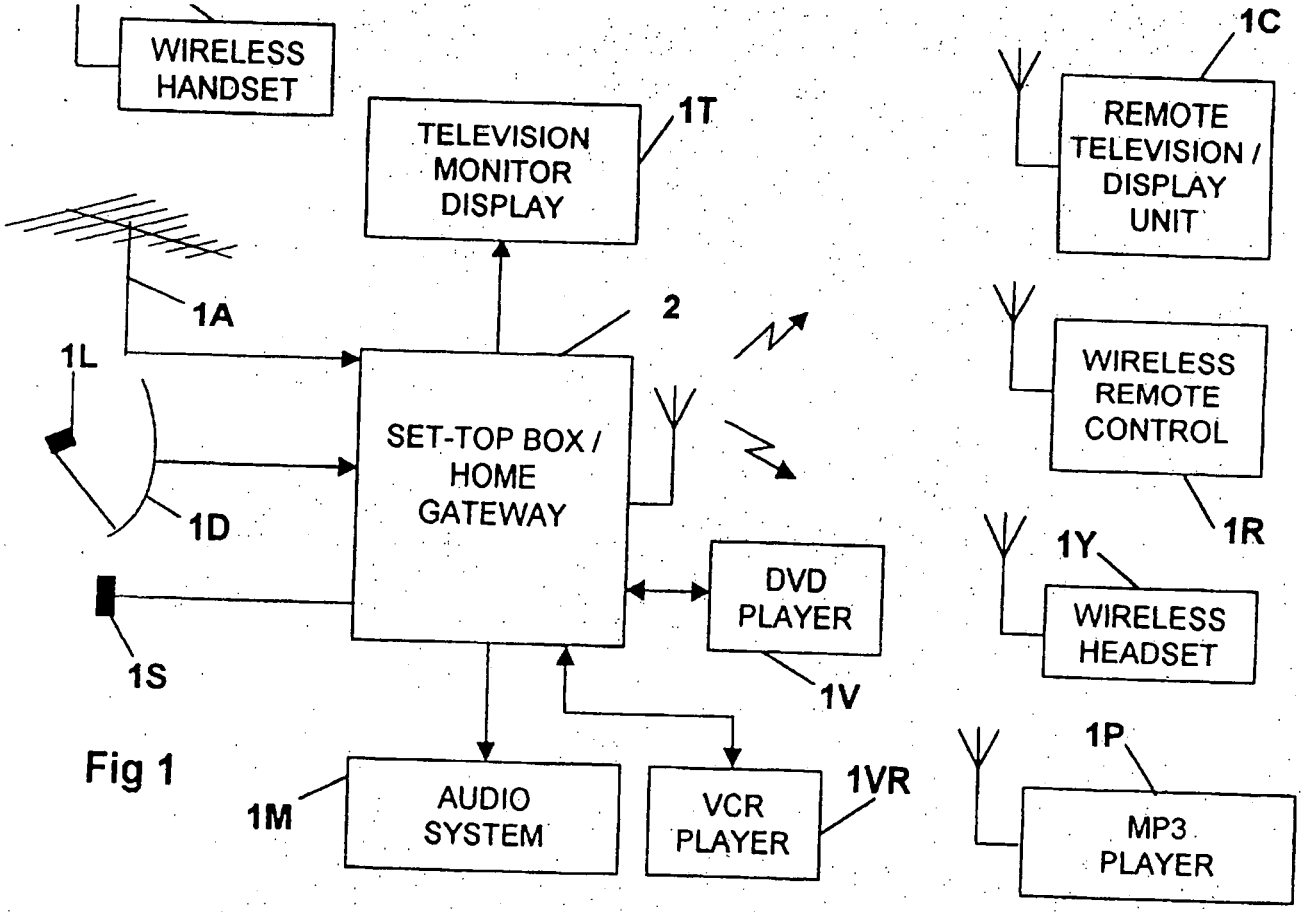

WIRELESS HANDSET
TELEVISION MONITOR DISPLAY
1T
1C
REMOTE TELEVISION / DISPLAY UNIT
1A
2
1L
SET-TOP BOX / HOME GATEWAY
WIRELESS REMOTE CONTROL
1D
1R
1Y
DVD PLAYER
WIRELESS HEADSET
1S
1V
1P
1M
AUDIO SYSTEM
VCR PLAYER
1VR
MP3 PLAYER

Fig 1

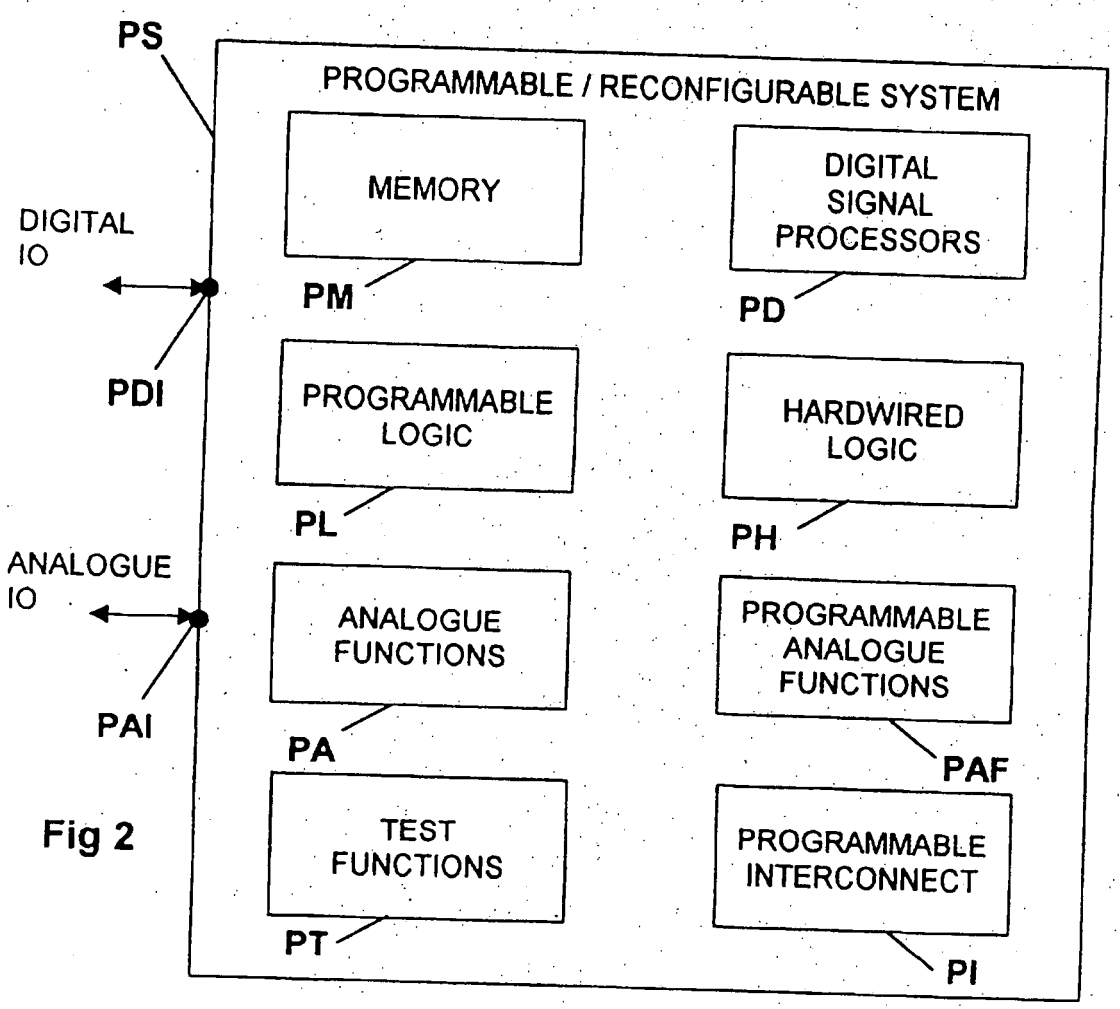

PS
PROGRAMMABLE / RECONFIGURABLE SYSTEM
MEMORY
DIGITAL SIGNAL PROCESSORS
DIGITAL IO
PM
PD
PDI
PROGRAMMABLE LOGIC
HARDWIRED LOGIC
PL
PH
ANALOGUE IO
ANALOGUE FUNCTIONS
PROGRAMMABLE ANALOGUE FUNCTIONS
PAI
PA
PAF
TEST FUNCTIONS
PROGRAMMABLE INTERCONNECT
PT
PI

Fig 2

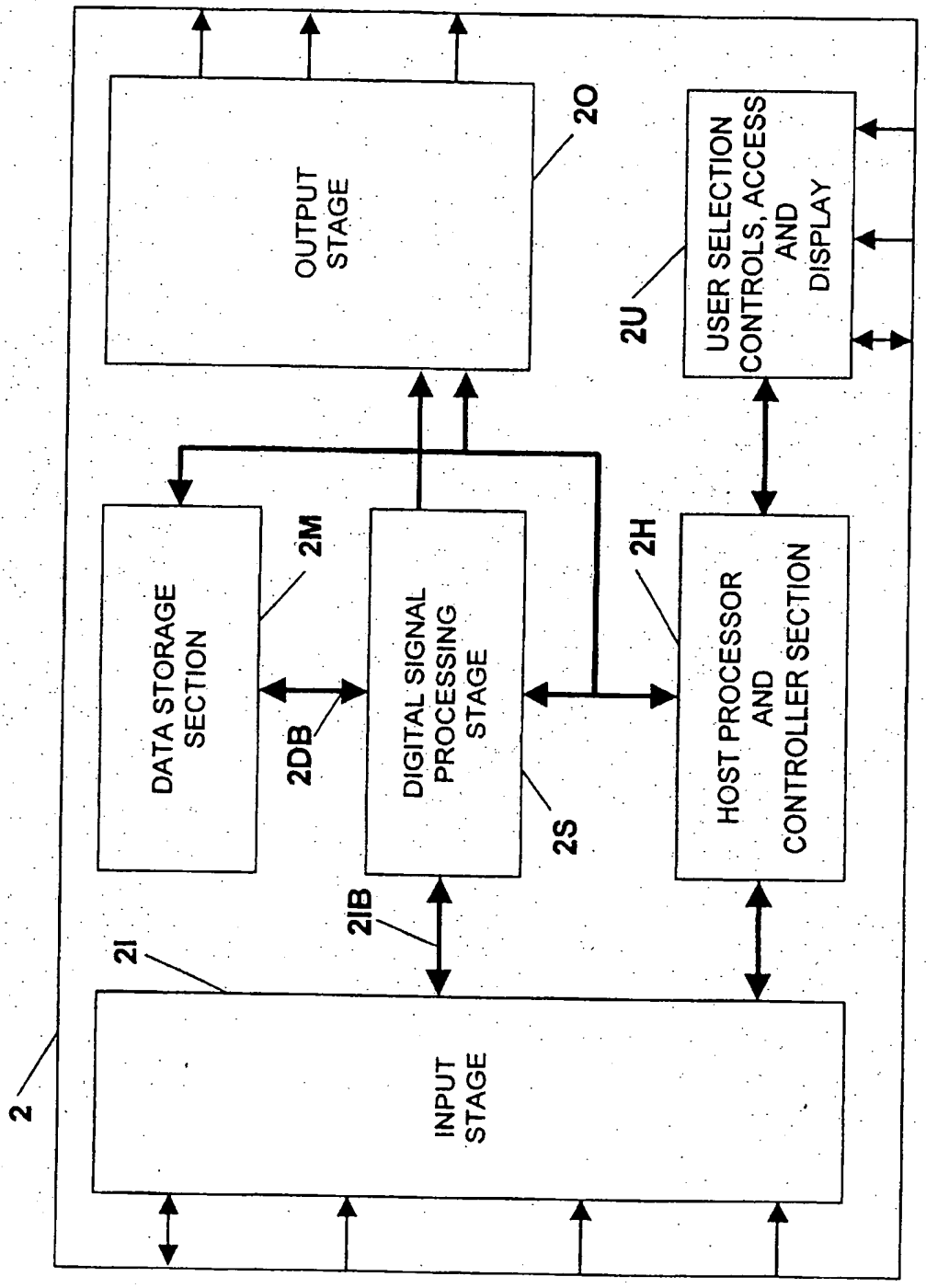
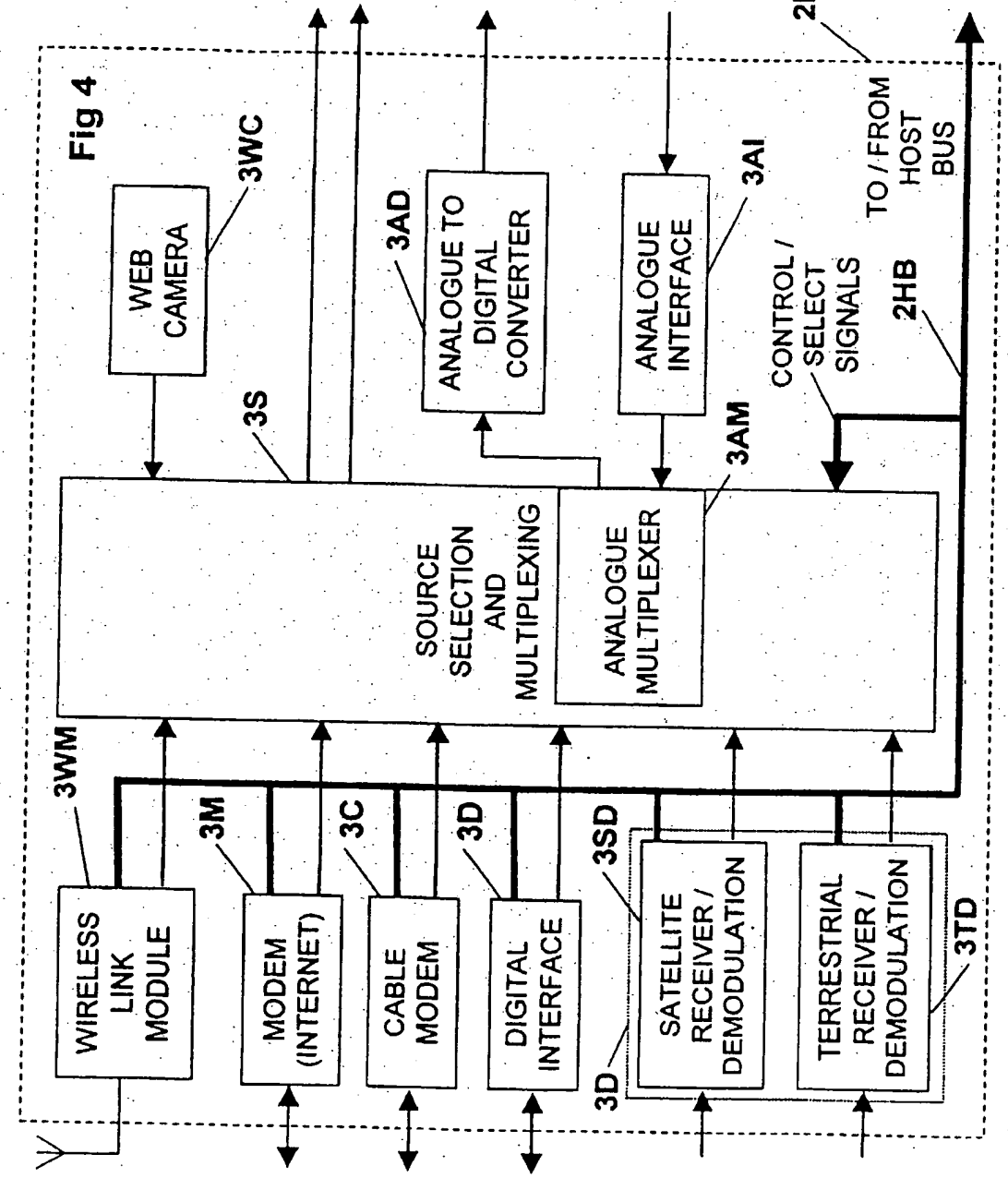

OUTPUT STAGE
2O
USER SELECTION CONTROLS, ACCESS AND DISPLAY
2U
DATA STORAGE SECTION
2M
2DB
DIGITAL SIGNAL PROCESSING STAGE
2S
2H
HOST PROCESSOR AND CONTROLLER SECTION
2IB
2I
INPUT STAGE
2

Fig 3

Fig 4


WEB CAMERA
3WC
3AD
ANALOGUE TO DIGITAL CONVERTER
ANALOGUE INTERFACE
3AI
2I
TO / FROM HOST BUS
CONTROL / SELECT SIGNALS
2HB
3S
3AM
SOURCE SELECTION AND MULTIPLEXING
ANALOGUE MULTIPLEXER
3WM
3M
3C
3D
3SD
WIRELESS LINK MODULE
MODEM (INTERNET)
CABLE MODEM
DIGITAL INTERFACE
SATELLITE RECEIVER / DEMODULATION
TERRESTRIAL RECEIVER / DEMODULATION
3TD
3D

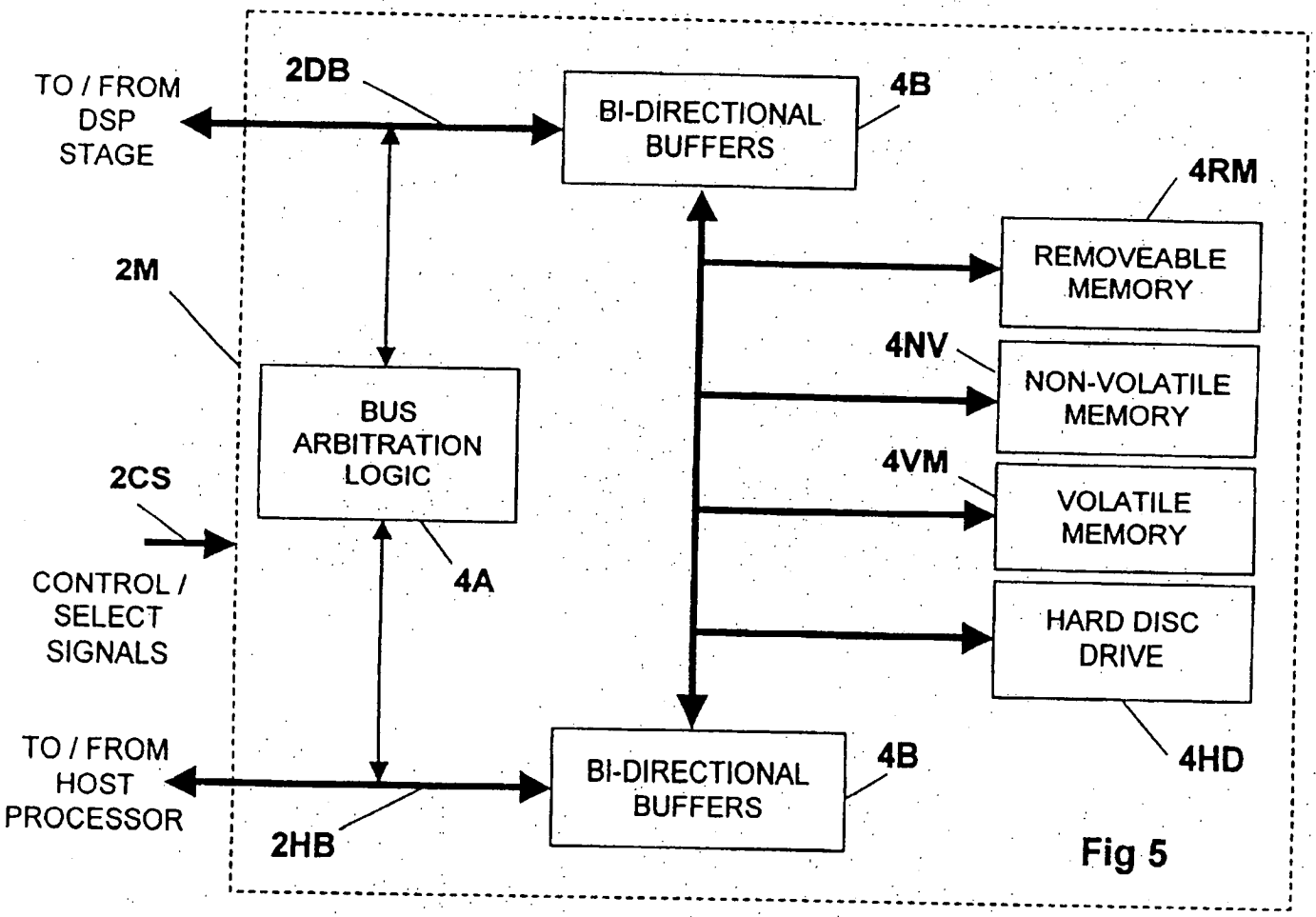

TO / FROM DSP STAGE
2DB
BI-DIRECTIONAL BUFFERS
4B
4RM
REMOVEABLE MEMORY
2M
4NV
NON-VOLATILE MEMORY
BUS ARBITRATION LOGIC
2CS
4VM
VOLATILE MEMORY
4A
CONTROL / SELECT SIGNALS
HARD DISC DRIVE
4HD
TO / FROM HOST PROCESSOR
BI-DIRECTIONAL BUFFERS
4B
2HB

Fig 5

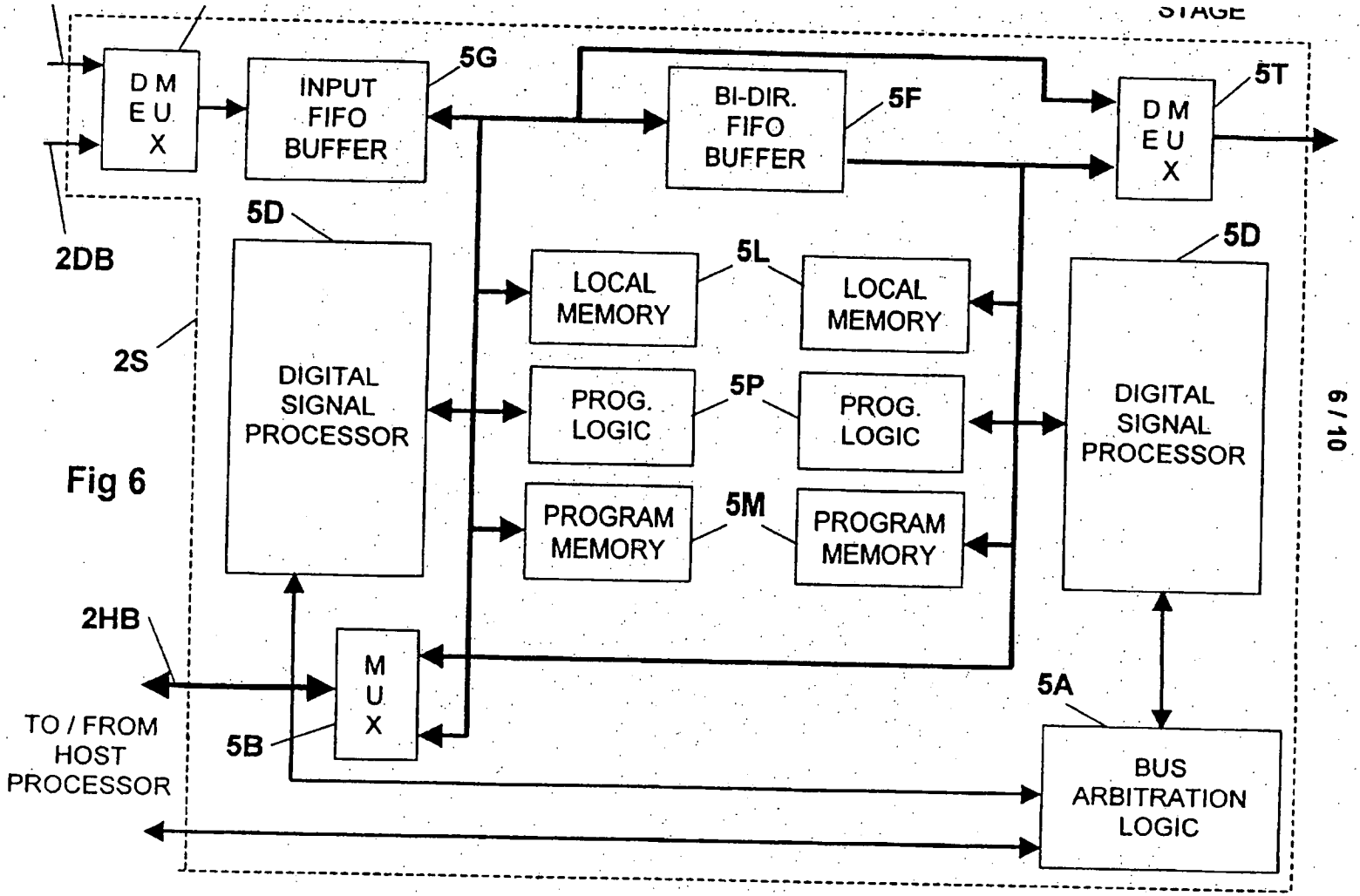

STAGE
D M E U X
INPUT FIFO BUFFER
5G
BI-DIR. FIFO BUFFER
5F
D M E U X
5T
2DB
5D
2S
DIGITAL SIGNAL PROCESSOR
LOCAL MEMORY
5L
LOCAL MEMORY
PROG. LOGIC
5P
PROG. LOGIC
PROGRAM MEMORY
5M
PROGRAM MEMORY
5D
DIGITAL SIGNAL PROCESSOR
2HB
M U X
5B
TO / FROM HOST PROCESSOR
5A
BUS ARBITRATION LOGIC

Fig 6

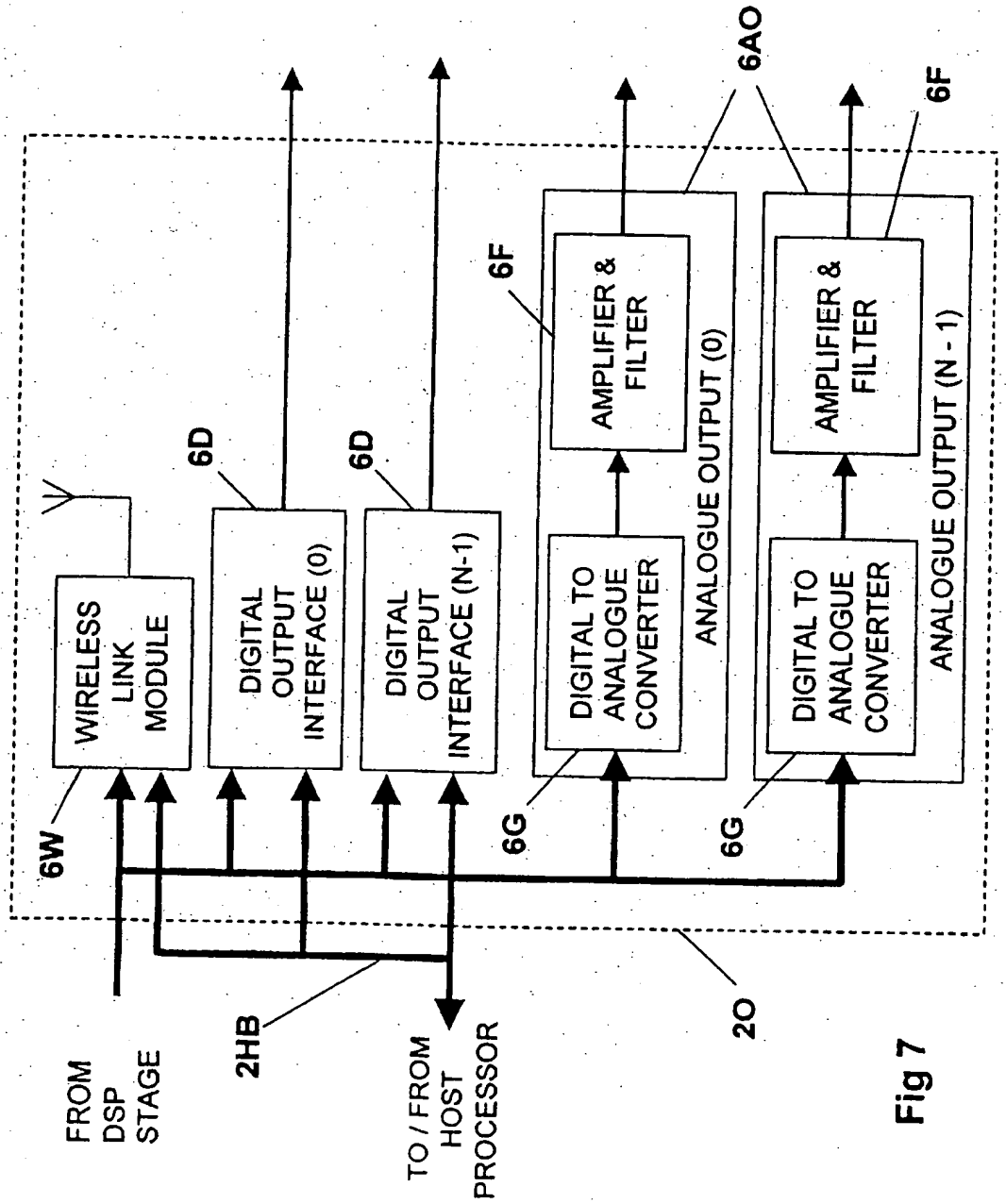

WIRELESS LINK MODULE
DIGITAL OUTPUT INTERFACE (0)
DIGITAL OUTPUT INTERFACE (N-1)
DIGITAL TO ANALOGUE CONVERTER
AMPLIFIER & FILTER
ANALOGUE OUTPUT (0)
DIGITAL TO ANALOGUE CONVERTER
AMPLIFIER & FILTER
ANALOGUE OUTPUT (N - 1)
6W
6D
6D
6F
6G
6AO
6G
6F
2HB
2O
FROM DSP STAGE
TO / FROM HOST PROCESSOR

Fig 7

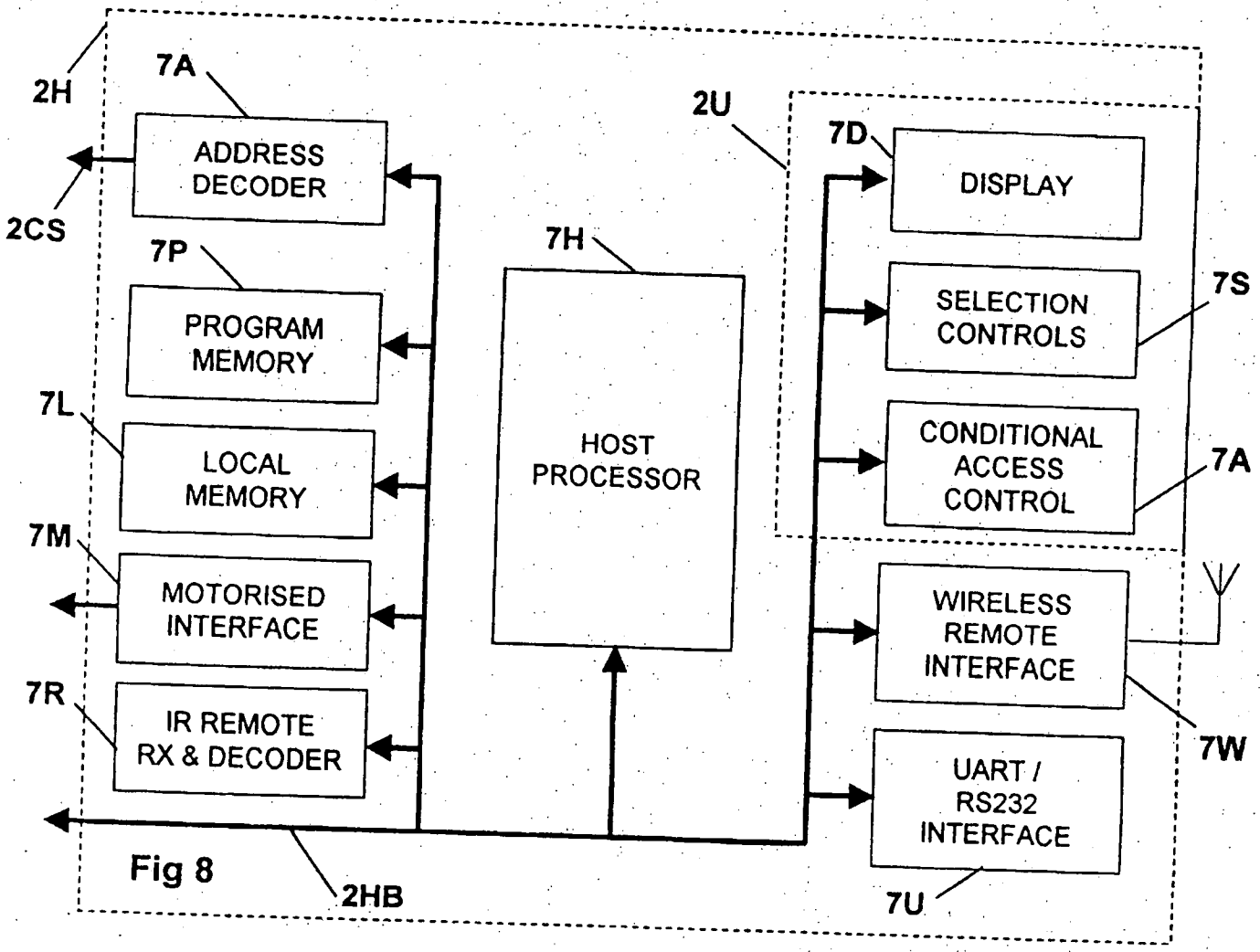

2H
7A
ADDRESS DECODER
2CS
7P
PROGRAM MEMORY
7L
LOCAL MEMORY
7M
MOTORISED INTERFACE
7R
IR REMOTE RX & DECODER
7H
HOST PROCESSOR
2U
7D
DISPLAY
SELECTION CONTROLS
7S
CONDITIONAL ACCESS CONTROL
7A
WIRELESS REMOTE INTERFACE
7W
UART / RS232 INTERFACE
7U
2HB

Fig 8

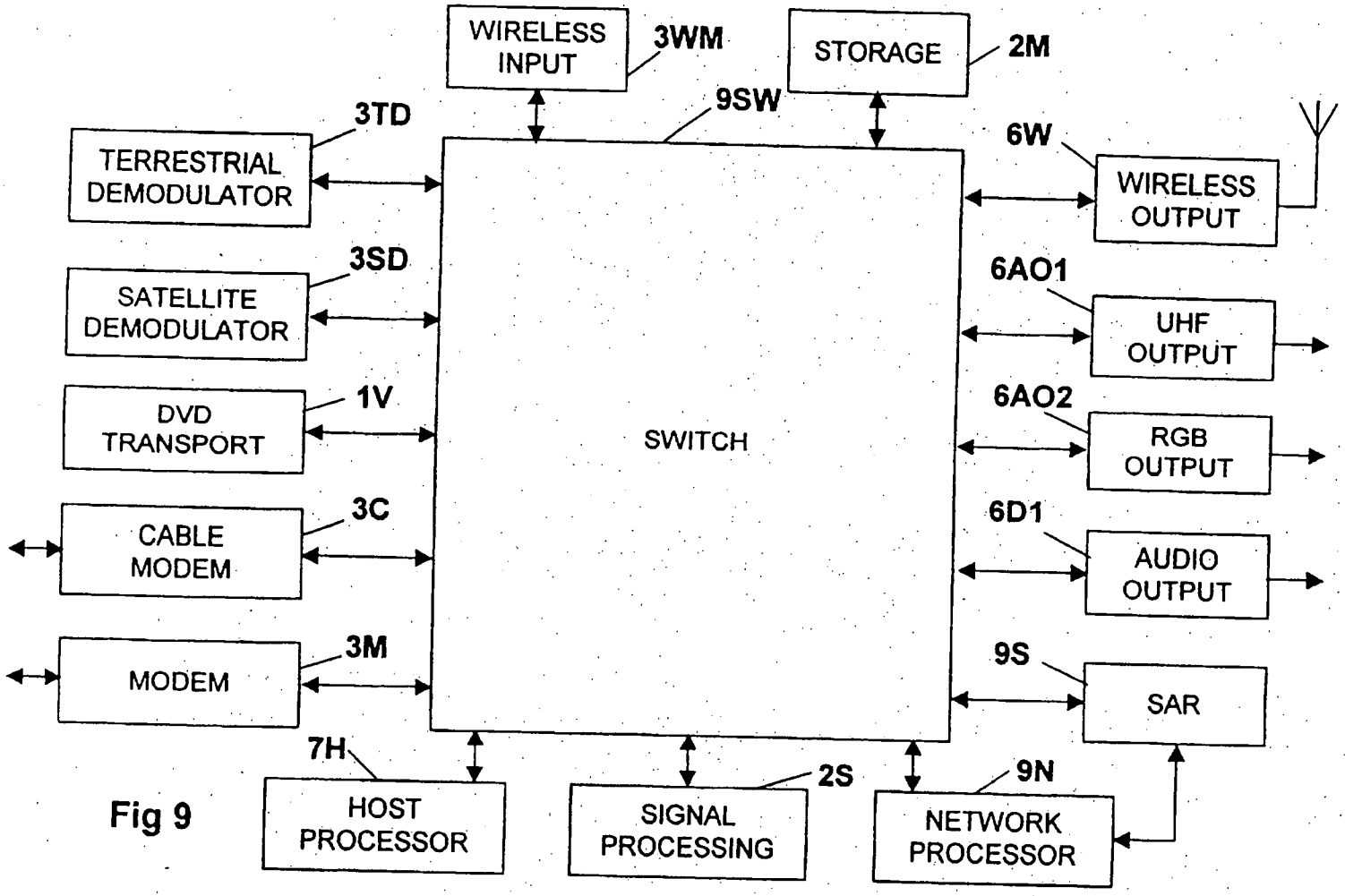

WIRELESS INPUT
3WM
STORAGE
2M
9SW
3TD
TERRESTRIAL DEMODULATOR
6W
WIRELESS OUTPUT
3SD
SATELLITE DEMODULATOR
6AO1
UHF OUTPUT
DVD TRANSPORT
1V
SWITCH
6AO2
RGB OUTPUT
3C
CABLE MODEM
6D1
AUDIO OUTPUT
MODEM
3M
9S
SAR
7H
HOST PROCESSOR
2S
SIGNAL PROCESSING
9N
NETWORK PROCESSOR

Fig 9

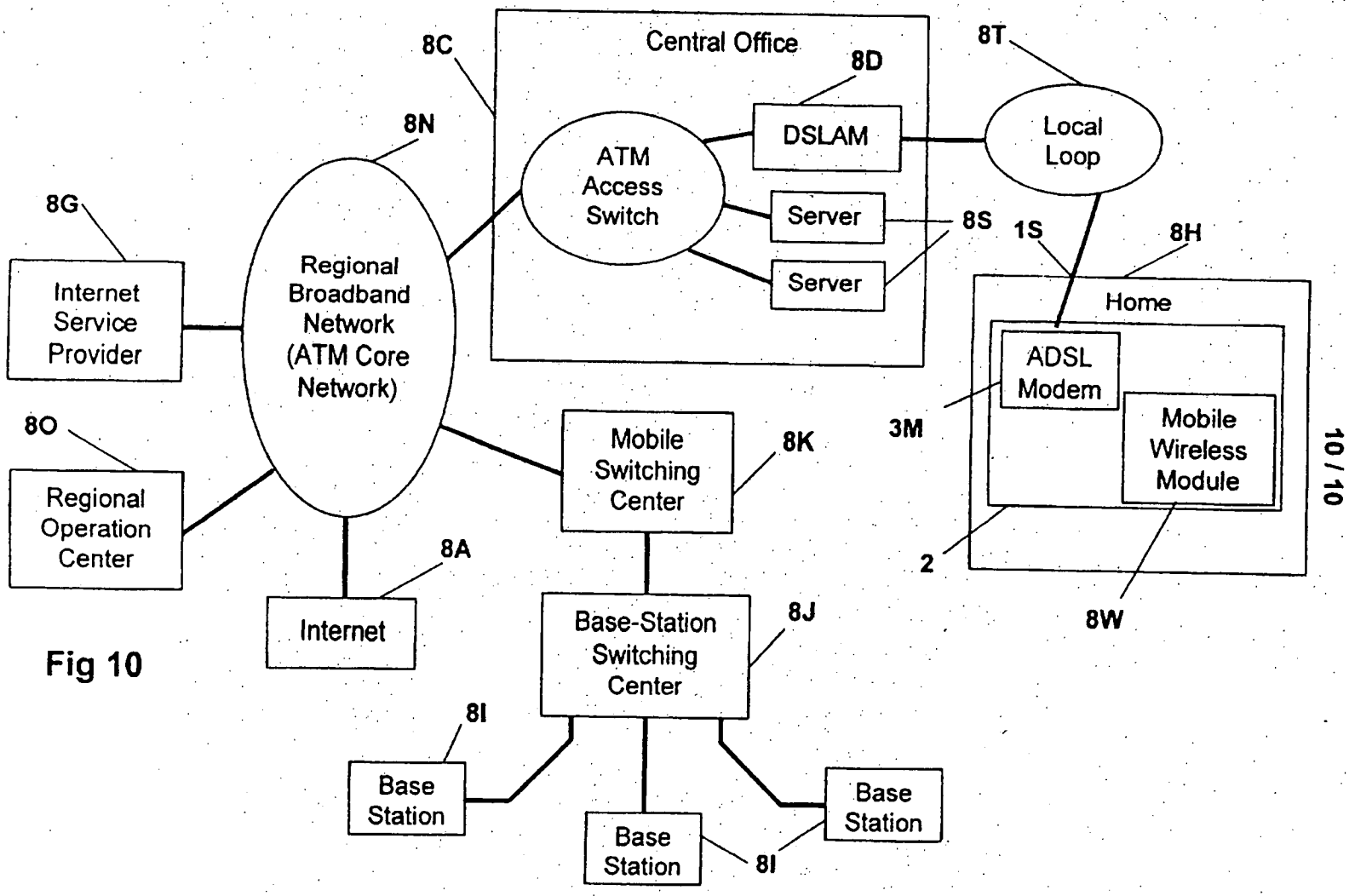

8C
Central Office
8D
8T
8N
DSLAM
Local Loop
ATM Access Switch
Server
8S
1S
8H
8G
Regional Broadband Network (ATM Core Network)
Server
Home
Internet Service Provider
ADSL Modem
3M
Mobile Wireless Module
8O
Mobile Switching Center
8K
Regional Operation Center
2
8W
8A
Internet
Base-Station Switching Center
8J
8I
Base Station
Base Station
Base Station
8I

Fig 10

TURE PROOF" SET-TOP BOX AND GATEWAY APPARATUS

ın relates to a more "future proof" set-top box and gateway

urrently several methods of receiving video and television ;, namely satellite, terrestrial and cable. These can be divided logue and digital formats. For each scheme there can also be lulation – demodulation techniques, compression schemes, ɔn schemes, encryption-decryption, forward error correction and ocols.

of the modulated information can use employ different carrier The C-band range is 3.70 – 4.20 GHz, the DBS band (intended broadcast is 11.70 – 12.40 GHz, and Ku band is in the range 0 GHz. The signals can also be vertically or horizontally llow more channels. There also exists several television format gital Video Broadcast (DVB), Multiplexed Analogue Circuits (D-) and Motion Picture Group (MPEG 2 and MPEG4). Some els employ a single transponder. This is known as Single Carrier. Others use Multiple Channels Per Carrier (MCPC). For ın a similar scenario applies. The symbol rate for each channel and is usually in the range of 2000 to 45000.

ew TV channels, users require a conditional access module decoding of the encrypted video signals. Again, several available. Viaccess, Conax and Seca Mediaguard are the three

hese services, there are many new standards being developed of transporting the various data to and from the services example, there are different methods of performing voice nd creating links to transfer voice information. Voice data could using conventional Plain Old Telephone Service (POTS), by or Voice Over Internet Protocol (VoIP). Each have their own ıd disadvantages. However, it is becoming more likely that ire at least one of these methods of voice transfer.

opment of more complex silicon devices for implementing DSP the growth in communications technologies like cable and the and more services are being delivered to the home via ATM, This includes television distribution over the Internet using col TV (IPTV). Likewise, wireless technology, such as eRF, WIFi and HiperLAN2, has reduced the need for cabling ment boxes, allowing equipment to be portable in the home. v the distribution of services around a home. For example, udio information received via the access gateway can then be

re-transmitted to different applications within a home negating the need to have separate decoding boxes at each location in a house. In fact, with the merging of these technologies in the future it is anticipated that "set-top boxes" will become a combination of a home gateway and a set-top box.

Apart from direct reception of transmitted television signals, other media exists to watch video information. Videotape, laser discs and Digital Versatile Disc (DVD). The latter supersedes the former two. However, to use these media a dedicated player unit is required. These are expensive and new standards render the equipment obsolete within a few years. Also, many of units employ duplicate electronics. For example, satellite decoders or set top boxes use MPEG 2 decoders, as do DVD players. Digital Audio Broadcast (DAB) also employs the audio section of the MPEG 2 standard as do MP3 players. This is an inefficient and expensive use of electronic circuits. Having a unit that has an MPEG 2 decoder which can be "multiplexed" between the various sources means the peripheral units are less complex and cheaper to produce. Another example would be that separate units require separate power supplies, remote control units, displays, microprocessors and memory. Having these system functions in a single unit which can be configured for use in different system configurations would be a much more efficient system. This approach provides a different system partitioning and architecture to that of conventional systems.

With the increase in silicon gate counts and the use of mixed signal technologies comes better system performance and the chance to implement new techniques and / or algorithms which exploit the improvements high speed, high resolution digital technologies bring i.e. graphics, 3D sound and high speed telecommunication transport. However, for manufacturers to gain market advantages and exploit greater processing power data needs to be transferred at every greater rates which requires new interfaces (such as Universal Serial Bus (USB), Firewire, xDSL and wireless access such as Bluetooth. Consequently, interfaces and processors are constantly being developed every 12 - 18 months requiring the customers to update their systems to stay "in touch". Though many of these systems are backward compatible, this leads to reduced performance, with systems requiring more software and processing power to execute the required functions. Also, not all manufactures sign up to the same interface consortiums and differences exist in similar equipment. An example would be the recent introduction of digital terrestrial television and digital satellite television in which both set top boxes use MPEG2 video transport but the former is received via a conventional television aerial and the latter by a satellite dish. Likewise, there is now a trend to introduce more sophisticated surround sound decoding, such as six and eight channel surround sound schemes provided by Dolby and the like. Thus current equipment is then obsolete. Of course, this is not a green or environmentally friendly approach.

One of the main disadvantages of these various systems is that they cannot be upgraded for use with new and or different standards. They do not evolve with changing standards. If a new service is introduced or a user wishes to access different satellites or change to terrestrial broadcast or cable, then they need to purchase a whole new system. A similar problem arises for the network and or service provider. As new technology is introduced the network and service providers usually need to update their equipment. An example would be when BSB was bought out by BskyB and all the squarial dishes and set top boxes need to be replaced. Then when Sky Digital replaced Sky analogue. This is expensive for the network or service provider as they subsidize the cost of the equipment.

This also makes it difficult for consumers to keep up to date with new technology. New standards and delivery protocols are constantly being developed e.g. MPEG4 and MP3, DVB-MHP, various surround sound and interactive features which means equipment can quickly become obsolete requiring the consumer to purchase new units if a new media type is adopted. Also the interfaces between units can change so interconnection between legacy equipment means that the units are incompatible. With the introduction of new media formats new systems require interface upgrades, which requires changing more than the interfaces, usually a whole system element needs to be replaced and new hardware and software installed. In fact, interfacing between system elements can be one of the most complex problems to overcome as many new interfaces rely on software protocols to implement their functionality. For example Universal Serial Bus (USB), Firewire (1394 standard) and UTOPIA Level 2 interfaces.

Being able to swap between the different formats without having to substitute whole equipment units would be a great advantage and cheaper for the consumer. Having a set-top box / home gateway unit which incorporated programmable logic in which the hardware devices can be configured (software – firmware definable) to implement new circuits and upgradeable to allow the equipment to evolve with changing standards would provide many advantages over current systems, namely:-

- Systems that evolve with changing standards – Equipment is more "future proof";
- This would provide a greater Return On Investment (ROI);
- Simpler and less expensive peripheral equipment;
- Same "programmable or reconfigurable circuitry" reconfigured to implement different algorithms, interfaces, word resolutions and functions (for example different types of digital filters) ;
- Expandable through the use of Plug'n'Play mezzanine cards and modules;
- Internet access for application and media downloads;

- Programmable and reconfigurable these features promote customisation and hence product differentiation;
- Optional hard drive for storing / retrieving video and audio data. Removable memory for use in other equipment e.g. MP3 players;
- Wireless connectivity (e.g. Bluetooth) alleviates the need for costly and cumbersome cabling;
- Multi-channel capabilities enable simultaneous use by more than one user.

Interconnection between the various equipment boxes requires many cables and tends to be unwieldy. It also means that a satellite decoder unit is dedicated to the system to which it is attached. Other remote devices cannot access the facilities provided by the satellite decoder apparatus. By employing a local wireless standard, such as Bluetooth, the received television programs could be distributed to remote television or display units in a home. This would alleviate the need for more than one set top box.

The reconfigurable "set-top box / home gateway " employs processor and programmable logic devices (PLDs) optionally incorporating embedded cores which allows the set-top box / home gateway to be reconfigured to implement various signal processing algorithms, protocols and interfaces. This provides a highly integrated and versatile audio-video / graphics processor and home gateway. This architecture and efficient system partitioning spells an end to built-in obsolescence. Consequently, this benefits the consumer as it reduces the need to purchase new equipment units when new standards are introduced. Firmware for current and future applications can be downloaded from the Internet via an integrated modem. This facility also allows access to Internet and future broadband services.

According to the present invention there is provided a set-top box / home gateway apparatus wherein some or all of the electronic circuitry is based on reconfigurable or programmable integrated circuit devices enabling the apparatus to be reconfigured by host processor means to implement new functions, algorithms, specifications and standards.

With such apparatus, manufacturers will be able to provide upgradeable apparatus to implement different standards and specifications. Users will then be able to "upgrade" the set-top box / home gateway apparatus without having to purchase new equipment boxes. In addition, the use of interchangeable card modules and or mezzanine cards, which can optionally incorporate programmable interfaces, enables a user will be able to easily add new functions and upgrades to the system by simply replacing, memory devices, mezzanine cards or individual card modules.

In an embodiment of the invention, certain system functions can be performed in software and or firmware. These types of functions include for example, digital filters, codecs, digital signal processing algorithms such as Fast Fourier Transforms (FFTs), Inverse Fast Fourier Transforms (IFFTs), noise reduction, surround sound algorithms, encryption and authentication. To perform these functions the software is run on microprocessors, Digital Signal Processors (DSPs) and or Reduced Instruction Set Computers (RISCs). This concept allows different sub functions required to form parts of the overall desired set-top box / home gateway to be implemented in software and run on a microprocessor. To allow for maximum flexibility, several processors and associated memory and Input - Output peripheral devices can be provided on a single motherboard or card module. As different set-top box / home gateway s require different sub-functions, the host controller can allocate the various software sub functions to various processors as necessary. For example, depending on the capabilities of the processor and the required functionality, a processor could run several software sub functions if the processing time permits and they are effectively sequential operations or the host controller could allocate different software sub functions to different processors and perform the required group of tasks in parallel.

This concept can be extend to include implementing system sub functions in programmable logic. The use of reconfigurable or programmable logic, such as Field Programmable Gate Arrays (FPGAs), is sometime required to implement more complex and time consuming algorithms, which are better, suited to hardware implementation. This gives rise to the concept of "Software Definable Systems". However, the use of programmable logic still requires the host controller to download firmware to program the programmable device to implement the desired sub function or sub functions required in the overall system configuration. These programmable logic devices can also include programmable analogue circuitry enabling many different analogue functions and circuits to be implemented.

The fact that programmable logic based systems provided the greatest flexibility (functional re-use and system re-configuration) in system design means that it is expandable and easily upgradeable. The main motherboard can have mezzanine card slots to allow the addition of more processors when a system needs to be expanded. The use of Plug'n'Play facilities means that the host processor can automatically determine the number and capabilities of the processors and or programmable logic devices available and hence allocate the desired resources accordingly.

Such a system can download new software and or firmware functions or upgrade existing functions from the Internet via an internal 3M modem or a cable modem 3C or external modem module or one of the downlink transmission channels from the satellite or terrestrial link.

A specific embodiment of the invention will now be described by the way of example with reference to the accompanying drawings, in which: -

Figure 1 shows a logical block diagram of the set-top box / home gateway apparatus and how it is connected, both by cable and wireless means to peripheral units:

Figure 2 shows a logical block diagram of the programmable and reconfigurable circuitry blocks used in set-top box / home gateway ;

Figure 3 shows a high-level logical block diagram of how the main blocks of the set-top box / home gateway are interconnected;

Figure 4 shows a high-level logical block diagram of the input section;

Figure 5 shows a high-level logical block diagram of the data storage section;

Figure 6 shows a logical block diagram of the signals processing stage;

Figure 7 shows a logical block diagram of the output stage of the set-top box / home gateway ;

Figure 8 shows a logical block diagram of the host processor and controller section of the set-top box / home gateway ;

Figure 9 illustrates an example of an overall system in which communications between the various sub blocks is by switching means.

Figure 10 shows an example of an end-to-end ADSL based broadband network architecture in which the set-top box / home gateway can transfer image data, together with audio and status information via an Internet connection or mobile phone connection.

In a preferred embodiment of the invention the set-top box / home gateway apparatus incorporates one or a plurality of programmable logic devices which can be configured (software – firmware definable) by a host processor to implement different functions, algorithms, specification and standards selected by the user. This allows the user to upgrade their equipment when new standards are introduced. Software and or firmware to implement these new functions, algorithms, standards and specifications are downloadable either via the Internet, or via a broadcast channel, or via a personal computer or directly from plug-in memory media or indirectly from optical memory media, such as CDs or DVDs.

To make the best possible use of the available resources programmable logic means can be reconfigured in real time to allow functional multiplexing or reuse of the programmable logic.

These programmable logic devices can also include programmable analogue circuitry enabling many different analogue functions and circuits to be implemented. The programmable circuit blocks of these programmable integrated circuit devices (full custom and or ASIC) can contain any combination of programmable digital logic, hardwired logic functions, programmable interconnect, analogue functions, programmable analogue circuits, memory storage means, embedded processor core means, input – output pins and programmable input – output circuits. The programmable logic on a device can also be configured to implement the architectures of different processor so the apparatus can be configured to implement software targeted at those particular processors, for example operating systems. This includes the implementation of a Java Virtual Machine (JVM), which is required to run Java code by converting the Java code to byte code targeted at the native processor.

In another embodiment of the invention, the host processor means can determine the performance and functional capabilities of the available processor and programmable logic resources. The host processor can then allocate the available resources to implement functions required to implement the selected specifications and standard. The host processor then configures the available processor(s) and programmable logic accordingly to implement these specifications and standards. In an enhanced embodiment, the apparatus can be interrogated by a remote host system to establish the configuration and performance of the apparatus, the remote host system can then transfer reconfiguration files for a selected specification or standard. These reconfiguration files being optimised of that particular apparatus. For example, the implementation of algorithms and functions can be split between software run on a processor and hardware implemented in programmable logic device. This method then optimises the available resources to the selected function.

In yet another preferred embodiment of the invention the set-top box / home gateway apparatus uses one or more programmable or reconfigurable circuit / logic blocks PS to implement signal processing functions. These logic blocks PS can be based on any combination of Digital Signal Processors (DSP) PD, RISC cores, programmable logic PL, such as FPGA / CPLD based circuits, hardwired logic PH, programmable interconnection PI to allow different routing of signals between circuit blocks, memory PM to store programs, data and configuration parameters. The devices can also include test function circuits PT to analyse and test the configured circuits and analogue functions PAF, which can also be programmable. Figure 2 shows a logical block diagram of such an arrangement where the programmable / reconfigurable system PS can be either a single device or more than one

device. Though silicon technology now allows mixed signal integration the programmable and reconfigurable function do not necessary have to be confined to a single device. They can be implemented using several devices. The programmable / reconfigurable system can also be implemented using any combination of processing cores, programmable logic, hardwired logic, memory, analogue functions, digital input / output pins PDI and or analogue input / output pins PAI. The logic blocks and devices are configured by the host processor based on the selected signal processing algorithm or algorithms required for a particular input output combination. These algorithms include MPEG2 processing for layers 1, 2 and 3 (MP3), MPEG4, decryption and de-scrambling schemes, various conditional access methods, different modulation and demodulation schemes, noise reduction, teletext data processing, audio and data processing, various interfaces and the like.

To cater for different system configurations and implementations a function, algorithm, standard or specification can also be implemented in various ways. The software-hardware partitioning can vary depending on the apparatus the function is being run on. To allow the greatest flexibility in system reconfiguration and programmability the apparatus can also include dedicated processing elements, such as microprocessors, Digital signal Processors (DSPs), Reduced Instruction Set Computers (RISCs) and microcontrollers, which work with the reconfigurable / programmable logic devices to implement the selected functions. Having programmable logic and processing arrays allows the host processor to configure the logic / circuit blocks and devices so certain signal processing functions can be efficiently allocated to the different blocks. In some cases, where processors and programmable logic devices operate at high frequencies, these logic blocks can implement several different algorithms by being re-configured in real time to perform multi-tasking. The control algorithms are stored in local memory at initialisation by the host processor. Examples of programmable logic to implement these functions include the FLEX and MAX series of devices from ALTERA. Configuration can also be stored locally in configuration EPROMs, such as the EPC1064. Having the program and re-configuration data stored locally is more efficient and doesn't become a processing burden on the host processor which would have to be a powerful processor operating at many MIPS to cater for all the interrupts and reconfiguring of the logic blocks during operation.

In addition, the use of Application Specific Integrated Circuits (ASICs) and System On a Chip (SOC) technology allows the integration of both programmable logic, standard cell logic, processing cores, such as RISC cores, and analogue functions. The programmable / re-configurable circuitry employed in the set-top box / home gateway apparatus 2 can also be based on this type of device technology as it can reduce device count and system costs. Figure 2 shows a generic programmable and reconfigurable block

containing among other things digital logic, analogue logic and IO. Both the digital and analogue logic and circuits respectively can be programmable.

The set-top box / home gateway apparatus 2 interfaces to several other peripheral devices. Figure 1 illustrates the concept, but is not limited to the devices shown. The set-top box / home gateway apparatus in this example receives video, audio and data information via a cable modem connection, a terrestrial channel or a satellite broadcast channel. The set-top box / home gateway apparatus 2 in connected via cables to a television display 1T and audio system 1M, such as hi-fi system or multi-channel audio processor 1M which implements digital theatre or surround sound algorithms. In fact, the audio processing can be incorporated within the apparatus 2 .The set-top box / home gateway apparatus 2 can be controlled and configured by a wireless remote control means 1R. The wireless communications method can be either infrared or a local wireless scheme, such as Bluetooth or IEEE 802.11 or HomeRF. The wireless remote control unit 1R also contains a large colour display to allow viewing of web pages when the apparatus is connected to the Internet for downloading web information, home shopping, surfing and updating the set-top box / home gateway apparatus with new applications and reconfiguration data.

The set-top box / home gateway can be configured to implement video, audio and data information distribution within a home. The remote television / display unit 1C communicates with the set-top box / home gateway via a local wireless link. This arrangement allows a user access the set-top box / home gateway apparatus 2 from a remote location. This has the advantage that the user doesn't have to purchase several set top boxes for different locations within a home. It also reduces the need for cumbersome and expensive cables. The wireless communication standards employed for local distribution include Bluetooth, HomeRF, WiFi, IEEE 802.11a, IEEE 802.11b, HiperLAN2 and HAVi .

Satellite, terrestrial and cable service providers optionally include radio and music channels as part of their service bundles. Included as part of the system is a wireless headset 1Y allowing a user to listen to audio signals output from the set-top box / home gateway apparatus 2. These audio channels, however, are not limited to just the pure audio services and can be used with the audio channels associated with a video channel.

The set-top box / home gateway apparatus 2 can optionally include a modem for Internet access. Modem specifications vary, as do the data transfer rates. For example, the modem could be a V.90 or an Asymmetrical Digital Subscriber Line (ADSL) modem or could be based on the programmable and reconfigurable logic so the host processor can configure the available logic / circuits to implement different modem types for different applications.

However, having Internet access allows a user to download information of various formats. MP3 files could be downloaded and stored locally on memory means in the set-top box / home gateway apparatus 2 or transmitted by wireless means to a MP3 Player 1P. Likewise, a wireless handset 1H can be used in conjunction with the set-top box / home gateway for audio communications via the Internet. The programmable and reconfigurable logic / circuits in the set-top box / home gateway apparatus 2 can be used to implement the Voice Over Internet Protocol (VoIP), thus allowing inexpensive voice communications worldwide.

The set-top box / home gateway apparatus **2** is made up from several sub-blocks. Figure 3 outlines the interconnection of the various sub-blocks, which make up the set-top box / home gateway apparatus 2. Other configurations are possible and the one shown in figure **3** is used to help describe the overall functionality. These are the input stage section 21, the digital signal processing stage **2S**, the data storage section 2M, the User selection controls, display and conditional access modules 2U, the host processor and controller section 2H and the output stage section 20.

A block diagram of the Input Stage section 21 is shown in figure 4. The input stage sub-block or 21 contains the circuitry to interface peripheral devices to the set-top box / home gateway 2. These devices include, but are not limited to, a remote control unit IR, a Digital Versatile Disc player or transport **1V**, a Low Noise Buffer (LNB) 1L of a satellite dish **1D**, an aerial **1A** for terrestrial broadcast and a web camera 3WC. Figure 1 shows a system example of how the set-top box / home gateway 2 uses wireless communication links to transfer data between itself and peripheral devices. However, the connection between the set-top box / home gateway 2 and the peripheral devices in the system do not have to be by wireless means and can be by cable means. Though several peripheral devices are shown in figure 1, this does not exclude other devices.

Input signals from a peripheral device, such as a video cassette recorder (VCR) or transport 1VR can be either an analogue format or a digital format. As all signal processing is performed in the digital domain any analogue signals have to be first converted into the digital domain using analogue to digital converters **(ADCs) 3AD.** The analogue to digital converters (ADCs) **3AD** will have the data resolution, sampling rate and other characteristics to correctly translate the analogue signals to digital signals without introducing any noise or aliasing affects. Though different systems use different resolutions the ADCs 3AD should have a minimum resolution of 8 bits and a maximum resolution of **32** bits. Devices include the Burr Brown PCM1700 or Crystal Semiconductor CS5394. Analogue signals are first buffered, amplified and filtered by the analogue interface 3AI. These signals are then passed to the analogue to digital converters **3AD** via an analogue multiplexer **3AM.** Several analogue input buffer circuits 3AI can be used, one for each analogue peripheral device.

al source selection from the analogue input buffers 3AI to the input of the gue to digital converters 3AD is controlled by the host processor 7H d on user inputs. The apparatus 2 could have several separate digital interfaces, which are applied to a multiplexer. The output of the plexer being determined by the selector input. This value is read by the processor, which then writes a value to the multiplex register (not n) to select the correct input. The multiplexer register being address ed.

l signals are also buffered using a digital buffer 3D before being input digital interface 3S. Source selection to the digital interface 3S is via gital multiplexer 3DM and is controlled by the host processor 7H based ser inputs. The digital interface 3S performs data formatting and ing for various digital audio protocols for both transmit and receive

put stage 2I can optionally include a modem 3M to be connected to the atus 2. The modem 3M could be an Asymmetrical Digital Subscriber ADSL) modem or cable modem 3C or a low speed modem (say a V.90 ant modem) for example and can take the form of a PCMCIA or PC hich can be inserted into a PC TYPE1 / 2 or 3 slot located on the tus 2. The software required to initiate, establish and control an t link is performed by the host processor and controller section 2H. ying a module approach as in the described apparatus allows les to higher performance systems easily and cheaply and access to edia types. The use of reconfigurable and or programmable logic / allows new modem standards to be implemented using the same s.

ceived from the various signals sources is output onto the host bus fter being processed by the relevant input circuitry. Commands to re and select the input circuitry are transferred from the host sor and controller section 2H via the Control / Select bus 2CS. tively, local decoding can be performed by decoding information ed on the control bus 2CS.

rther embodiment communication between the set-top box / home y apparatus 2 and the peripheral devices is by wireless means. This es the need for expensive and cumbersome connection cables n the various signal source devices or peripherals. However, the use ess communications between the apparatus 2 and peripheral devices preclude the use of wired connections. Section 3WM is a wireless lule which is used to allow digital data from a peripheral device, such note control 1R to be received by the set-top box / home gateway 2. vireless links can be bi-directional allowing two-way communications n the set-top box / home gateway 2 and any of the peripheral devices. ormation could include control data to control the peripheral device

via the set-top box / home gateway 2 using a "universal" remote control unit 1R, which would be used to select a new track for example. The wireless section 3WM can be integrated as part of the apparatus 2 or be a removable module, similar to a PC TYPE 1, 2 or 3 card or mezzanine card. These self-contained modules would be easily inserted and removed from the apparatus 2 making then very user friendly. The use of "Plug'n'Play" technology means that at start-up, the host processor 7H will perform a routine to search and establish what hardware is available in the apparatus 2 and configure the apparatus 2 accordingly.

The host processor and controller section 2H performs all the 'housekeeping' tasks including reading values input via the input selection controls and display circuitry 2U. The updated and selected values being displayed on display means 7D, such as an LCD display 7D. Figure 8 shows a block diagram of the host controller and controller section 2H together with the user selection controls and display module 2U. An Infra-red remote control interface 1R allows user commands to be received, demodulated, decoded and passed to the host processor 7H. These values being transferred to the corresponding logic block or blocks so they can be used by the audio processing algorithms. Communication between the set-top box / home gateway apparatus 2 and the remote control means 1R can be either an infrared protocol, such as IrDA or a wireless protocol such as Bluetooth. In the latter cases, a wireless remote interface 7W will be required. However, as wireless protocols such as Bluetooth and HomeRF allow multiplexing of several channels only one wireless section 7W is required for the basic system. Due to the modular nature of the apparatus 2 additional wireless circuits 7W or 3WM can be added if necessary to implement more complex multi-channel systems. In this case more than one remote control 1R can be used with the set-top box / home gateway apparatus 2.

Pay to view channels are encrypted or scrambled using various encryption algorithms. Some also require an authentication procedure. To de-scramble the received information and view the desired programs the set-top box / home gateway apparatus needs a conditional access module which usually employs SMART cards containing viewer information. The conditional access module or circuits 7A can be a plug in module or logic / circuitry based on programmable and or configurable logic. This architecture allows different conditional access algorithms to be implemented, changed and upgraded either via the Internet or a broadcast channel. Of cources, free to air services do not require the conditional access functions so using a plug-in module is easier for manufacturing purposes, though the conditional access circuitry can be implemented directly on the motherboard. This is desirable, as a user may wish to access more than one satellite transponder which are operated by different service providers. Software, such as the DisEqC, is available to control several LNBs or dishes and allow a motorised dish to locate the desired satellite signal.

Any system configuration will require a control means to initialise, control and monitor system performance. This will be provided by the host processor and controller section 2H. Software driver routines to control the various card functions will be stored in non-volatile program memory means 7P, such as FLASH Memory. Figure 8 shows a logical block diagram of a Host Processor and controller section 2H, which incorporates the display 7D and the remote control functions 7R and 7W. Selecting the desired system configuration and modifying the variable parameters, such as volume and tuning, is either by front panel controls or via a Hand-Held Remote Control unit 1R. Instructions are transmitted to the set-top box / home gateway apparatus 2 using an infrared or wireless link. These signals are received and decoded by the IR remote control receiver and decoder 7R. Chosen parameters are consequently displayed on the LCD display 7D. Reception of signals or changes to front panel settings causes an interrupt to the Host Processor 7H. The host processor 7H services the interrupt and updates the corresponding system parameters by addressing the relevant function and writing the relevant data to the appropriate control registers. In the case of the display 7D and remote control circuitry 7R / 7W, data is passed to the host processor 7H via host bus means 2HB.

The remote control 1R can also be used for selecting interactive features and sending information back to the service and or network provider via the modem means 3M / 3C. This not the only interactive feature provided by the set-top box / home gateway apparatus 2. A so-called web camera or web cam 3WC can be connected to the set-top box / home gateway apparatus 2. Again, the connection can be either wired or wireless. This facility gives rise to the concept of the virtual contestant. Video data sourced by the web cam 3WC is encoded and transmitted back to the network or service provider via the modem means 3M / 3C. This video data can then be processed by the network and or service provider for distribution as part of a program allowing all valid subscribers to view the video data. Due to the limited bandwidth of Internet and return channels the video data would need to be compressed. Various algorithms exist to perform the compression and new ones are constantly being introduced. MPEG2 and MPEG4 are the most popular. The programmable and or reconfigurable logic / circuitry can configured to implement these algorithms to provide this service. The configuration would be implemented by the host processor 7H. Any new application or reconfiguration data can be downloaded from the Internet and stored locally in memory 7P or hard disk drive 4HD.

In a further embodiment of the invention the interactive facilities allow a user to change the colour of received video or graphics to a colour of their choice. They can also select the font types for displayed text. Another feature allows the user to position different video and graphics at different points on the display. In addition to these features, means are available to allow either the user and or the service provider to limit the amount of detail within a program to be displayed. For example, greater resolution features, textured

information, teletext information, mapped graphics which enhance an image. These extra details could be available with extra subscriptions. Likewise, some programs may have contents which a user doesn't wish their children to watch. By determining the level of content the user can hide certain areas or parts of images or audio. This latter audio function would allow bad language and swear words to be either removed or replaced by appropriate language. Once programmed, the apparatus 2 will then perform real-time audio editing.

There are several interactive standards being developed, such as DVB-MHP. The programmable circuits within the apparatus will allow these additional features to be implemented as they are introduced. Thus increasing the life cycle of the apparatus 2.

The remote control 1R can also be used to type in text information for transmission via the modem 3M as emails. The set-top box / home gateway 2 can also be configured to receive Internet data, such as emails. These can be stored and viewed on the display means 1T or 1R or 1C. The apparatus 2 can also be used to view other services which are provided by the service provider and licensed by the service provider. One such example would be home banking.

The various programs to implement the different algorithms and configure the logic blocks are stored in host program memory 7P. This has the advantage that the processor 7H can allocate the different sub programs to different logic blocks depending on the number and type used in the set-top box / home gateway apparatus 2. The host processor 7H will at start-up or initialisation "interrogate" the various logic blocks to discovery what type and how many logic blocks are available in the system so it can determine how to efficiently configure the system to perform the selected signal processing algorithms and or protocols. Also, certain card modules or mezzanine modules will incorporate Plug'n'Play means, which allows card modules to initialise and or assist in configuring themselves.

Local memory 7L is used by the host processor 7H for storing parameters and variable used in processing. The address decoder circuitry 7A is used to decode addresses placed on the host bus 2HB by the host processor 7H and generate chip select signals for the various logic blocks in the apparatus 2.

The address decode circuitry 7A is shown in figure 8 as a local block, but the address decoding could be performed elsewhere in the apparatus 2. For example, each section could employ its own address decoding (not shown). To allow a Personal Computer (PC) to be connected to the apparatus 2 a UART / RS232 interface 7U is provided (Maxim MAX202) for example. This could be used to control the apparatus 2, or perform diagnostic testing, or download new application routines or algorithms to the host program memory 7P via the host processor 7H for example. Though an RS232 interface is

shown in figure 7 other interfaces could be used, such as a Universal Serial Bus (**USB**) interface or a Firewire interface.

Though the apparatus **2** allows "video data" (video data can also include audio and alpha-numeric data) to be sourced in various formats from peripheral devices, such as a Digital Versatile Disc player or transport 1V or a VCR 1VR for example, the set-top box / home gateway apparatus **2** also has the facilities to store, retrieve and processes "video data" stored internally on a hard disk drive **4HD**, non-volatile memory **4NV**, volatile **4VM** and removable memory cards 4RM. The hard disk drive **4RM** can take the form of a magnetic disk drive or an optical disk drive, such as a compact disc or Digital Versatile Disc (DVD). These can also be read / write-able allowing stored or edited "video data" to be stored on the magnetic and or optical disk media. Figure 5 shows a block diagram of the data storage section 2M and how access to the various memory blocks is achieved. Access to the data storage section 2M is via two ports, namely the digital signal processing stage 2S and the host processor and controller section **2H.** Therefore, the memory in the data storage section **2M** is considered dual port and arbitration logic 4A is required to control access to the memory in the data storage section **2M.** This will take a conventional form of having bus request and bus grant signals. Arbitration will however ensure no one block has more than its fair share of accesses to the memory by locking out the other processor.

Hard disk drives **4HD** have limited capacity and new drives with greater capacity are constantly being introduced. To allow greater storage the "video data" will be compressed to reduce memory storage. The compression algorithms include MPEG2, MPEG4 and wavelet compression. Again, the programmable and or reconfigurable logic / circuits can be configured to implement new compression algorithms as they are introduced. The "video data" will be written to the hard disk drive **4HD** under the control of the host processor **7H** or signal processing section **2S.** The source of the "video data" can be from the peripheral device or more likely from a broadcast or the Internet via an internal modem means **3M.** For example, the user would open an Internet connection using the apparatus **2** and modem **3M.** The selected video data would be downloaded from the Internet and stored on the hard disc drive 4HD or non-volatile memory **4NV** or volatile memory 4VM or removable memory card **4RM.** This data would be passed to the data storage section 2M via the host bus 2HB. The host processor 7H having to arbitrate (bus arbitration logic **4A**) to access the memory. To isolate the non accessing processor from data being either stored or retrieved from internal memory by the accessing processor, bi-directional tri-state buffer **4B** are employed. This latter arrangement allows both the host processor 7H and the digital signal processing stage 2S to operate in parallel and both gain access to the data storage section 2M.

In another embodiment, the apparatus 2 has mechanical and electronic interface means to allow the user to insert removable and interchangeable hard disk drives 4HD and or optical drives 4HD and or memory cards 4RM into the apparatus 2. The optical drives can be read or read-writeable. These removable memory means may contain previously stored "video data" which can then be read, processed and output by the apparatus 2. Or new "video data" can be stored onto the removable memory means 4HD or 4RM by the apparatus 2. Having interchangeable hard disk drives 4HD allows the user to upgrade the apparatus 2 easily and cheaply. The host processor 7H will detect the changes and configure the apparatus 2 accordingly. The set-top box / home gateway apparatus 2 can be programmed to record data from various sources, such as a satellite broadcast, terrestrial broadcast or Internet broadcast, at a predefined time allowing the user to retrieve and view the stored data at a later date. The data to be recorded is stored on the hard disk drive 4HD or non-volatile memory 4NV. The video data can also be recorded to memory means 4HD and or 4RM in real time.

As the interfaces and processing logic / circuits are optionally programmable and can be reconfigured to implement various standards, protocols and formats; much of the logic and or circuitry usually implemented in conventional units can be implemented in the set-top box / home gateway 2. For example, satellite decoders or set top boxes use MPEG 2 decoders as do DVD players. Digital Audio Broadcast (DAB) also employs the audio section of the MPEG 2 standard as do MP3 players. This is an inefficient and expensive use of electronic circuits. Having a unit that has an MPEG 2 decoder which can be "multiplexed" between the various sources means the peripheral units are less complex and cheaper to produce. In this example, there would be no need for a conventional DVD player. Only a DVD transport would e required, which could be inserted into the apparatus 2. Another example would be that separate units require separate power supplies, remote control units, displays, microprocessors and memory. Having these system functions in a single unit which can be configured for use in different system configurations would be a much more efficient system. This approach provides a different system partitioning and architecture to that of conventional systems which is more efficient, flexible and versatile.

Once the user has selected the "video data " source the video apparatus 2 needs to process the "video data" and output the data streams to the selected peripherals. The processing required depends on the format of the source data and the settings of the controls. The data could be encrypted, need filtering and reformatting. Signal processing will need to be applied to implement the various decompression algorithms. In some cases analogue signats to need be processed. Associated audio data will also need processing and can also take one of several formats. Providing standard logic circuitry to process the various formats would be expensive and unwieldy. Employing programmable logic, such as FPGAs and digital signal processors would allow the same hardware to be re-configured to implement

and process the selected data format and protocols. This is also true for the input and or output interfaces. Another advantage of employing programmable logic devices means that upgrades are easily implemented and the apparatus can be configured to use new data formats or interfaces. This concept of reconfigurable or programmable systems means the set-top box / home gateway apparatus 2 is more "future proof" and shouldn't become obsolete as quickly.

As mentioned previously, the programmable logic is not just confirmed to standard products. The use of Application Specific Integrated Circuits (ASICs) and System On a Chip (SOC) technology allows the integration of both programmable logic, standard cell logic, processing cores, such as RISC cores, and analogue functions. The programmable logic / re-configurable circuitry employed in the set-top box / home gateway apparatus 2 can also be based on this type of device technology as it can reduce device count and system costs. Figure 2 shows a generic programmable and reconfigurable block containing among other things digital logic, analogue logic and IO. Both the digital and analogue logic and circuits respectively can be programmable.

Figure 7 shows a block diagram of the output stage section 2O. This section formats the processed data from the digital signal processing stage 2S for transmission to the selected peripheral devices. Many of the components in the output stage 2O will need to be initialised and configured to implement the desired interface protocol. These components, such as the wireless link module 6W, the digital output interfaces 6D, are configured by the host processor 7H via the host bus 2HB. Processed digital data from the digital signal processing stage 2S can be output in analogue format, digital format or transmitted in a wireless format. The digital output interfaces 6D receive digital data from the digital signal processing stage 2S and format the received data into an appropriate format for transmission to the selected equipment. Depending on the interface and protocol, the format of the digital means that several digital channels can be multiplexed on the one channel. Alternatively, a digital output interface 6D can be provided for each channel.

Though a single bus 2HB is shown, this is just an example of the interconnection method. Someone experienced in the art will realise that more than one interconnection bus can be employed where speed and parallel activity is required.

Many legacy peripherals, such as a VCR 1VR or display employing a SCART connector 1T will have analogue inputs. Therefore, signals output from the set-top box / home gateway apparatus 2 will need to be converted into an analogue form. Consequently, digital signals output from the digital signal processing stage 2S are input to digital to analogue converters 6G, such as an Analog Device AD1857.

The output of each digital to analogue converter 6G is then low pass filtered to "smooth" the signal and then amplified, buffered and impedance matched using circuitry 6F. The digital to analogue converter 6G and the filter and amplifier circuitry 6F can be combined to form an analogue output module 6AO. Different analogue output modules are available. Section 6AO1 is a UHF output module which takes a video and audio data and modulates it so resultant signal can be applied directly to a conventional television set. Section 6AO2 provides RGB video signals together with associated audio signals for connection via a SCART connector, for example. Section 6D1 is an audio output module for use with multi-channel audio processor, such as Dolby Prologic® or Surround Sound® systems or THX® or Digital Theatre Systems®. The audio output Section could also be an analogue output module (not shown) for connection to conventional hi-fidelity amplifiers.

Though a separate audio system 1M can be used, set-top box / home gateway apparatus 2 can be combined with audio circuitry 1M on the same PCB board or unit or a plug-in module. The circuitry required to implement the audio processing can also be programmable allowing new and different audio standards to be implemented.

In some applications, the communication between the set-top box / home gateway apparatus 2 and other equipment, such as a headset 1H or power amplifier 1P, will be by wireless means. This allows such equipment to be positioned in a remote location. It also means equipment in other locations in a home can utilise the facilities provided by the set-top box / home gateway apparatus 2 negating the need for more than one set-top box / home gateway apparatus 2.

Accordingly, digital data output from the digital signal processing stage 2S is input to the wireless link Section 6W where it is processed and formatted for transmission to the selected equipment. The wireless protocols used can be DECT or Bluetooth or HomeRF for example, but are not limited to these wireless protocols. As wireless protocols, such as Bluetooth and HomeRF can multiplex many data channels (up to eight for Bluetooth) then the functionality provided by the wireless Section 6W could be provided by the other wireless Section named in the apparatus. Therefore, wireless blocks 3WM, 7W and 6W can effectively be the same wireless Section and are shown as different functional blocks in the corresponding diagrams to assist in the explanation of the function of the individual sub-blocks.

In yet another embodiment, the apparatus can be enhanced and upgraded through the use of interchangeable mezzanine cards. These facilities provide additional flexibility and allows manufacturers to add extra capabilities. These mezzanine or card modules can be plugged directly into the motherboard. Alternatively, they can connect to the motherboard via a backplane PCB. Users will then be able to "construct" a set-top box / home gateway apparatus and use existing card modules to build new configurations. As the

card modules and or mezzanine cards can optionally incorporate programmable interfaces, a user will be able to easily add new functions and upgrades to the system by simply replacing, memory devices, mezzanine cards or individual card modules. Any backplane used can transfer data of different format by encapsulation techniques. The backplane is based on high-speed differential serial connections (up to 600 Mega-bits per second). This facility provides adequate means for future system performance. Of course, new, higher speed interface could easily be added to a card module to incorporate future high-speed inter-card module communications.

In another embodiment, the software and or firmware definable logic blocks can be implemented on daughter cards or mezzanine cards, which can be inserted into the main motherboard. This allows the user to easily expand the set-top box / home gateway capabilities. For example, the user might have purchased the basic set-top box / home gateway apparatus 2 initially for use as a satellite decoder, but would now like to access different transponders or access cable television.

Or he/she may have an analogue decoder and want to swap to a digital decoder. By adding extra functions or swapping plug-in cards to the main motherboard, the video apparatus 2 can be expanded to cater for these new configurations. Other daughter cards or mezzanine cards could include input interface cards, demodulation cards or output interface cards allowing more output channels to be accommodated.

In yet a further embodiment, the software and or firmware definable logic blocks can be implemented in removable cards, such as a PC TYPE 1 / 2 / 3 card. These cards can have programmable functions or fixed functions, such as a modem or WorldSpace satellite radio receiver. To reduce the complexity and duplication of circuitry employed in peripheral equipment some of the processing of the received data can be performed by the logic in the set-top box / home gateway . For example, in conventional Hi-Fi or home entertainment systems separate equipment units employ the same functional blocks to perform certain signal processing. Set Top Boxes (STBs), Digital Versatile Disc (DVD) players and Digital Audio Broadcast (DAB) receivers each use MPEG 2 audio decoders. The set-top box / gateway apparatus 2 can be configured to implement MPEG 2 audio decoding. Therefore, DVD players 1V and WorldSpace receivers, for example, can be manufactured without this circuitry. Consequently, data streams output from these simpler units can be input to the set-top box / home gateway apparatus 2 which would be able to implement and perform these common functions e.g. MPEG 2 audio decoding. This has the advantage of reducing the cost and complexity of the DVD players and WorldSpace receiver units. In the case of the reduce functionality DAB receiver, the unit only needs to perform the RF demodulation, filtering and decoding to extract the data streams from the DAB modulated signal. Another example of reduced functionality peripherals would be a Digital Versatile Disc (DVD) transport 1V in which the apparatus

implements the electro-mechanics of spinning and controlling the disc, disc loading and ejection, controlling the read / write head and providing an interface for read / write data streams. The read data stream can then be processed by the software / firmware definable logic circuitry. Likewise, processed write data would be transferred from the apparatus 2 to the DVD transport 1V for storing on the DVD media (not shown). The host processor 7H configuring the definable logic and processing elements (software algorithms run on various processors) so the set-top box / home gateway apparatus 2 is correctly configured to implement the processing circuitry / functions for the desired system configuration.

In another preferred embodiment, the set-top box / gateway apparatus 2 can be configured to be used by one or more users simultaneously. With sufficient processing power (perhaps through the addition of extra plug-in cards) the apparatus 2 can process signal data from more than one source and transmit it to several separate peripheral devices. This would alleviate the need to purchase more equipment. For example, one user could watch a satellite broadcast while the other watches a DVD whose data is transmitted by wireless means to a remote display 1C in another location in the home. In another example, the logic and circuits in the set-top box / home gateway 2 can be configured to allow more than one broadcast channel to be decoded, processed and output. In another example, the set-top box / home gateway apparatus 2 could be connected to more than one satellite dish 1D and or terrestrial aerial 1A to allow demodulation, decoding and simultaneous processing of received data from more than one signal source.

Figure 4 shows a logical block diagram of the digital signal processing stage 2S. The digital signal processing stage 2S comprises one or more digital signal processors 5D. Associated with each digital signal processor 5D is the program memory 5M used to store signal processing programs, local memory 5L used to store parameters used in algorithm / protocol calculations and programmable logic 5P which can be configured in real time or non-real time to implement various hardware functions required to for signal processing algorithms. To allow new software and configuration data, for the programmable logic 5P, to be updated the host processor 7H can gain access to the local memory 5L, the program memory 5M and the programmable logic 5P. To achieve this the host processor 7H must use the bus arbitration logic 5A. The host processor 7H will issue a bus request to the bus arbitration logic 5A. If access is allowed a bus grant signal will be sent back to the host processor 7H. Data is passed to the digital signal processing stage 2S using the host bus 2HB. Figure 4 shows an example of the signal processor and programmable logic architecture. This is just an example of the architecture and interconnection method. The set-top box / gateway apparatus is not limited to this architecture and is shown as an example to help describe the functionality. Someone experienced in the art will realise that different architectures and interconnection schemes can be employed where speed and parallel activity is required.

The digital signal processing stage 2S accepts data from both the input stage 2I and the data storage section 2M. Data from the data storage section 2M is transferred on bus 2DB. Depending on the configuration the user can have more than one bus 2DB. Data from the input stage 2I in transferred on bus 2IB. These two buses are connected to a demultiplexer 5S whose output is connected to an input fifo buffer 5G. The use of a fifo buffer 5G allows data read and write to and from the buffer 5G to be performed in bursts and at different clock rates. This arrangement improves system operation and partitioning by allowing the different sub-blocks to operate at their own rates and reduces complex sub-block communication. Processed data can be transferred to the output stage 2O directly via the demultiplexer 5T or directly via the bi-directional FIFO buffer 5F then through the demultiplexer output stage 2O directly via the demultiplexer 5T or indirectly via the bi-directional FIFO buffer 5F then through the demultiplexer 5T. The use of the FIFO 5F allows the separate sub-blocks to operate at their own rates and so allows intercommunication between the digital signal processors 5D.

Although figure 1 shows a generic block diagram of the set-top box / home gateway apparatus 2 other sub-module interconnection methods can be employed. In one preferred embodiment (not shown), data and control transfer from data sources to data processing and data sinks between the various sub-blocks and card modules is by data packets. These card intercommunications are all digital using serial or differential serial communications links so as to reduce the number of signals and reduce signal noise between the sub-blocks and card modules. Therefore, any analogue signals are first converted to corresponding digital signals using appropriate digital to analogue signal conversion means. The selection of such conversion means ensuring the correct sampling and quantization requirements to represent the digital form of the signal with minimal quantization and noise errors. The data packets preferably being of the same length as used in the Asynchronous Transfer Mode (ATM) protocol or may be varying length packets.

The switching means 9SW can take the form of a pure cross bar switch in which signal paths between the switch inputs and switch outputs are dynamically set by the host processor 7H depending on the configuration of the apparatus 2. The switching means 9SW can also be a self routing buffered switch fabric in which data packets are transferred from the switch's input ports to the switch's output ports based on routing information contained in the header section of the data packet. As several inputs could route data packets to the same switch output port, buffering is required. To reduce congestion different priority queues could be used in the switch 9SW to allow higher priority traffic preference over lower priority traffic. This allows real time traffic and traffic requiring a better class of service to pass through the switch fabric 9SW with a lower latency and hence reduce timing errors. The switch paths and header fields are set by the host processor at system start-up or if there is a new configuration update.

The advantages of using a switch 9SW to route data packets between different sub-blocks, card modules and devices are that it reduces the complexity of the interconnection. Each card slot does not require connections to all other possible card slot locations. Control and data messages can be switched to the correct sub-block, card module and or device via the switching means. This makes it easier to configure the system and allows the card modules to be placed almost anywhere in the apparatus card slots as the host processor 7H card can interrogate each cards to determine it's function and initialise it and the system accordingly. Also, certain card modules can incorporate Plug'n'Play means, which allows card modules to initialise and or assist in configuring themselves. Another preferable feature is for the card modules to be 'hot swappable'. This feature allows cards to be removed or inserted into the apparatus 2 while the system is operational.

In another embodiment, the logic and circuits in the set-top box / home gateway 2 can be configured to allow more than one broadcast channel to be decoded, processed and output. For example, using Asynchronous Transfer Mode (ATM) broadband transmission over an ADSL modem 3M connection numerous channels can be received and decoded. The segmentation and reassembly (SAR) logic 9S can process many separate data streams. The SAR 9S segments data streams into packets of the same length for transmission. Likewise, received packets are combined to retrieve the original data. For ATM system different segmentation and reassembly protocols exist. These are named AAL0 – AAL5 and different AALs are used for different types of traffic e.g. variable bit rate (VBR) and constant bit rate (CBR). To ensure quality of service various traffic management, policing and scheduling schemes are employed. These functions can be implemented by the SAR 9S, the host processor 7H or the network processor 9N. The network processor 9N can also perform interworking functions. This allows different transmission protocols to be used or data to be encapsulated. Examples of a network processor 9N are the Helium processor from Virata.

Each ATM data packet contains a cell header and channel identifier. The same is true for IP traffic. This allows cells for each channel to be identified, processed and output to the desired destination interface.

Video data transfer can be implemented using one of several protocols. However, for communications over a Plain Old Telephone (POTs) network 8T it is envisaged that the information transfer will be MPEG (2 or 4) over ATM over ADSL for video and Internet access by IP over ATM over ADSL (if an ADSL modem 3M is employed). This type of configuration is outlined in figure 10. This assumes the set-top box / home gateway 2 is connected to a Digital Subscriber Line Access Multiplexer (DSLAM) 8D in at the central office 8C, as shown in figure 10. An ADSL modem 3M allows data rates of up to 8Mbits per second across conventional twisted pairs. Once a connection is established to either an Internet Service Provider (ISP) 8G or a video service

provider (server farms providing Near Video On Demand (NVOD) for example), video data can be transferred in both real time and non real time to the set-top box / home gateway apparatus 2 in the home 8H. A set-top box / home gateway 8S could be provided locally in the central office 8C. For non-real time transfers the video data can be stored on the hard disk drive 4HD. For non ADSL modems, such as a V.90 modem 3M, the set-top box / home gateway apparatus 2 is connected to the Internet 8A via the Plain Old Telephone (POTs) network 8T.

In addition, the set-top box / home gateway apparatus 2 can have a mobile wireless section or module 8W for connection to a mobile phone network. The mobile phone section or module 8W communicates like a normal mobile phone with a base station 8I. The base stations are connected to the base station switching centre 8J. These in turn are connected to the mobile switching centre 8K which connect to the Plain Old Telephone (POTs) network 8T. Though a GSM mobile network is shown in figure 10, the mobile network can be any other mobile network standard, such as a third generation (3G) mobile network, UMTS or broadband wireless (HiperLAN 2).

In yet another preferred embodiment, the set-top box / home gateway apparatus 2 can be configured to implement the functions of a games console. Games programs stored on memory card, DVDs or CDs can be inserted into the corresponding interface or transport provided by the apparatus 2 or a peripheral. The remote control unit 1R optionally having controls to provide interaction with the games software and manipulate the generated graphics accordingly. In some cases, game software may require different video processing. Much of this can be implemented by the digital signal processor and or the reconfigurable logic in the set-top box / home gateway apparatus 2. Alternatively, extra plug-in cards may be required to enhance the performance of the set-top box / home gateway 2, such as a graphics processor (not shown). However, a generic plug-in card containing programmable logic and a DSP could be used to implement such functions. The host processor 7 configuring the logic and circuits to implement the required graphics processing. By selecting the game console configuration, the host processor 7H will allocate the required resources to implement the decoding, processing and outputting of the graphics data to the display means 1T or 1C. Again, the modular, programmable and reconfigurable nature of the set-top box / home gateway 2 means that a separate games console unit is not required. Also, improvements in graphics standards means that whole new games consoles don't have to be purchased each time they are introduced. Incremental upgrades are possible, making the set-top box / home gateway much more "user friendly".

In another embodiment, the set-top box / home gateway apparatus 2 incorporates a Global Positioning System (GPS) receiver. This facility in conjunction with the host processor 7H and conditional access section or module 7A allows the apparatus 2 to determine its location and configure the

apparatus 2 to automatically select and tune to any terrestrial channels (if terrestrial decoding is selected) or to various satellite transponders for which the subscriber is allowed to view. The apparatus 2 would have available channel information for each region pre-programmed or the apparatus 2 could download this information from the Internet via the internal modem 3M.

The set-top box / home gateway 2 can take several forms (not shown). It could be implemented in single equipment box, one or more equipment boxes or on PCBs which are remove-ably insertable into a card frame. The main PCBs having both mechanical and electronic interface means to accept plug-in mezzanine cards.

Although the invention has been described herein with reference to particular preferred embodiments, it is to be understood that these embodiments are illustrative of the aspects of the invention. As such, a person skilled in the art may make numerous modifications to the illustrative embodiments described herein. Such modifications and other arrangements which may be devised to implement the invention should not be deemed as departing from the spirit and scope of the invention as described and claimed herein.

A

CLAIMS

1. A set-top box / home gateway apparatus wherein some or all of the electronic circuitry is based on reconfigurable or programmable integrated circuit devices enabling the apparatus to be reconfigured by host processor means to implement new functions, algorithms, specifications and standards.

2. A set-top box / home gateway apparatus as claimed in Claim 1, wherein the programmable circuits of a reconfigurable or programmable integrated circuit device can contain any combination of programmable digital logic, hardwired logic functions, programmable interconnect, analogue functions, programmable analogue circuits, memory storage means, embedded processor core means, input – output pins and programmable input – output circuits.

3. A set-top box / home gateway apparatus as claimed in Claim 1 or Claim 2, wherein the programmable circuits of a reconfigurable or programmable integrated circuit can be configured to implement the architectures of different microprocessors, digital signal processors or RISC processors or microcontrollers allowing the apparatus to be reconfigured to run different operating systems and software.

4. A set-top box / home gateway apparatus as claimed in Claim 1, wherein one or more functions or algorithms are sub-divided into sub-functions so parts of the function or algorithm are implemented in sofware run on a microprocessor or digital signal processors or RISC processor or microcontroller and other sub-functions are implemented in programmable logic.

5. A set-top box / home gateway apparatus as claimed in Claim 1 wherein the software and or firmware to reconfigure the programmable logic is downloaded from the Internet via an integrated modem means.

6. A set-top box / home gateway apparatus as claimed in Claim 1 wherein the software and or firmware to reconfigure the programmable logic is downloaded from a personal computer means via either cable or wireless means.

7. A set-top box / home gateway apparatus as claimed in Claim 1 wherein the software and or firmware to reconfigure the programmable logic is downloaded via a satellite, terrestrial or cable broadcast channel.

8. A set-top box / home gateway apparatus as claimed in Claim 1 wherein the software and or firmware to reconfigure the programmable logic is downloaded via interchangeable memory means or optical memory means.

9. A set-top box / home gateway apparatus as claimed in any preceding claim, wherein the host processor means can determine the performance and functional capabilities of the available processor and programmable logic resources, the host processor then being able to allocate the available resources to implement functions required to implement the selected specifications and standard, the host processor then configuring the available processor(s) and programmable logic to implement these specifications and standards.

10. A set-top box / home gateway apparatus as claimed in any preceding claim, wherein the programmable logic means can be reconfigured in real time to allow functional multiplexing or reuse of the programmable logic resources.

11. A set-top box / home gateway apparatus as claimed in any preceding claim, wherein the apparatus can be interrogated by a remote host system to establish the configuration and performance of the apparatus, the remote host system can then transfer reconfiguration files for a selected specification or standard, the reconfiguration files being optimised of that particular apparatus.

12. A set-top box / home gateway apparatus as claimed in any preceding claim, which includes a network processor to perform, control and process protocol transfers between the apparatus and a remote node.

13. A set-top box / home gateway apparatus as claimed in any preceding claim, which includes a host processor means and associated program memory means for controlling, monitoring and configuring logic and circuits to implement the functions required to receive, process and output a valid selected channel

14. A set-top box / home gateway apparatus as claimed in any preceding claim which includes modem means, allowing Internet access so the user can download upgrade firmware or software for implementing new signal processing algorithms and protocols and or configuring the programmable logic hardware and or signal processing algorithms allowing the programmable logic and processing elements in the apparatus to be reconfigured to implement the new algorithms and or hardware configurations, the new firmware and software being stored in non-volatile memory optionally under the control of the host processor, the Internet access also allows the user to download broadcast information, such as real-time video data, which can then be processed and optionally stored by the apparatus before being output to other peripheral apparatus.

15. A set-top box / home gateway apparatus as claimed in any preceding claim, wherein the programmable circuit blocks of an integrated circuit device can contain any combination of programmable digital logic, hardwired logic functions, programmable interconnect, analogue functions, programmable analogue circuits, memory storage means, embedded

processor core means, input – output pins and programmable input – output circuits.

16. A set-top box / home gateway apparatus claimed in Claim 1, wherein the interactive facilities means allows the user to manipulate the style and presentation of the displayed video and graphics data.

17. A set-top box / home gateway apparatus claimed in Claim 16, where in the received colour information can be mapped to a different colour, and or font types can be interchanged, and or graphics and video sections can be repositioned to desired screen positions and or the displayed and audio content can be user or service provider selectable.

18. A set-top box / home gateway apparatus as claimed in any preceding claim, which has one or a plurality of conditional access section or modules which can optionally be based on programmable and or software / firmware definable logic allowing the apparatus to be configured to implement different decryption, authentication and descrambling algorithms.

19. A set-top box / home gateway apparatus as claimed in any preceding claim, which can simultaneously receive, demodulate, process, optionally store and or output more than one broadcast channel from either the same transmission source and or separate transmission source means.

20. A set-top box / home gateway apparatus as claimed in any preceding claim, which can receive, demodulate, process, optionally store and output received broadband transmission broadcasts based on broadband mobile phone standards.

21. A set-top box / home gateway apparatus as claimed in any preceding claim, which communicates with a remote control means either by wired or wireless means, the remote control means allowing text and command data to be transferred to the apparatus and optionally having display means to display received data.

22. A set-top box / home gateway apparatus as claimed in any preceding claim, wherein the input signal to the apparatus from source means and or the output signals from the apparatus to signal sink means is by wireless communication means.

23. A set-top box / home gateway as claimed in claim 22 in which the wireless protocol used to transfer data to and from the apparatus is Bluetooth, HomeRF, WiFi, IEEE 802.11a, IEEE 802.11b, DECT, HiperLAN2, HAVi or Wireless ATM.

24. A set-top box / home gateway apparatus as claimed in Claim 1, which includes mechanical and electronic interface means to accept a fixed or remove-ably insertable hard disk drive used to store and retrieve video and associated audio and data information received by the apparatus.

25. A set-top box / home gateway apparatus as claimed in Claim 24, wherein the received data is compressed before the data is written to the hard disk.

26. A set-top box / home gateway apparatus as claimed in Claim 24, wherein the hard disk drive means is an optical disc means.

27. A set-top box / home gateway apparatus as claimed in Claim 1, wherein semiconductor memory means is employed to store and retrieve received information.

28. A set-top box / home gateway apparatus as claimed in Claim1 in which the apparatus can be configured for simultaneous use by more than one user where signal data from one or more signal sources can be processed and output to one or more output circuits.

29. A set-top box / home gateway apparatus as claimed in any preceding claim, which can be configured to decode, process and output game software, the output being displayed on display means, the remote control means having input control means to allow interaction with the apparatus to control the processing of the games software.

30. A set-top box / home gateway apparatus as claimed in Claim 1, wherein interface means is provided to allow connection of a web camera so video and associated audio data can be transmitted via modem means to the service and or network provider for use in their broadcasts.

31. A set-top box / home gateway apparatus as claimed in Claim 1, wherein one of the interchangeable modules provides receiver and demodulation means to receive satellite radio transmissions, such as WorldSpace®.

32. A set-top box / home gateway as claimed in Claim 1 which has the facilities to allow removable memory means, such as a PC TYPE 1 / 2 / 3 card or memory stick® to be inserted into the apparatus and removed from the apparatus, previously stored data being read from the removable memory means and processed by the apparatus before being output, alternatively processed data and or digitised signals, formatted in the selected format, can be stored in non-volatile memory in the removable memory card allowing the user to play the recorded data on another apparatus which has the facilities to access the data stored on the removable memory card means.

33. A set-top box / home gateway as claimed in any preceding claim, wherein digital switching means are employed to route and transfer data from different sub-blocks, card modules and or devices in the apparatus.

34. A set-top box / home gateway as claimed in Claim 33, wherein the digital switching means takes the form of a cross bar switch or a self-routing

switch in which data packets or cells have an appended routing tag to control the flow of the packet or cell through the self-routing switch to its destination.

35. A set-top box / home gateway as claimed in Claim 33, wherein the digital switching means uses priority output queues to allow data with different priorities to be queued in separate queues to reduce congestion and head of line blocking.

36. A set-top box / home gateway as claimed in Claim 33, wherein digital data for transfer via switching means is encapsulated as a variable length data packet or same length cell.

37. A set-top box / home gateway apparatus as claimed in any preceding claim, wherein more than one remote control means is provided.

38. A set-top box / home gateway as claimed in any preceding claim, wherein an external modem means is employed to access the Internet.

39. A set-top box / home gateway as claimed in any preceding claim which incorporates Analogue to Digital converter (ADC) means to allow analogue input signals to be first converted to digital signals so they can be processed in the digital domain, the sampling frequency of the Analogue to Digital Converter(s) (ADCs) being sufficient to accurately represent the signal in the digital domain.

39. A set-top box / home gateway as claimed in Claim 1, which incorporates interface means to accept additional card modules and or interchangeable mezzanine cards.

40. A set-top box / home gateway as claimed in Claim 39, wherein the interchangeable mezzanine card and or card module interface means are based on programmable logic, for example Field Programmable Logic Arrays (FPGAs) so upgrades can be easily implemented by changing the interface devices of the associated card module and or mezzanine card.

41. A set-top box / home gateway as claimed in Claim 39 wherein the mezzanine cards and or card modules incorporate 'Plug and Play' means to allow a mezzanine card and or card module to configure and initialise itself and interact with the host processor means to indicate the configuration, status and functionality of the card module and associated mezzanine card modules.

42. A set-top box / home gateway as claimed in Claim 40 or Claim 41 wherein the mezzanine cards and or card modules incorporate the means to be hot swappable allowing card module insertion or removal from the apparatus while the apparatus is operational.

43. A set-top box / home gateway as claimed in any preceding claim in which a personal computer (PC) can be connected to allow control of the

apparatus, reconfigure the apparatus, diagnose the apparatus and or download or upload data, which can be processed or stored in internal memory form future use.

44. A set-top box / home gateway as claimed in Claim 1 in which the input circuitry and or output circuitry is based on programmable logic devices, such as Field Programmable Gate Arrays (FPGAs), allowing the interfaces to be re-configured to implement the desired interface protocol or format.

45. A set-top box / home gateway as claimed in any preceding claim in which the remote control means can be used to control the peripheral signal source apparatus.

46. A set-top box / home gateway as claimed in any preceding claim, in which the apparatus can have some of the programmable circuitry configured to implement functions and or algorithms normally performed in "conventional" peripheral equipment allowing new peripheral equipment which operates with the said set-top box / home gateway apparatus to have reduced functionality.

47. A set-top box / home gateway as claimed in any preceding claim in which the apparatus can be programmed to record received data using "non-volatile" memory means at a predefined time so it can be retrieved, processed and output at a later time.

48. A set-top box / home gateway as claimed in any preceding claim where peripheral units are situated remotely from the set-top box / home gateway apparatus in which control and data messages are transferred by wireless means allowing movement of the said remote peripheral units to different locations within the user's house without the need to re-wire the apparatus.

49. A set-top box / home gateway as claimed in any preceding claim which incorporates an integrated read and optionally write-able Digital Versatile Disc (DVD) transport and associated control circuitry to allow stored digitised audio data to be read and or written to a Digital Versatile Disc (DVD) media.

50. A set-top box / home gateway apparatus as claimed in any preceding claim, which allows the transmission and reception of electronic mail.

51. A set-top box / home gateway apparatus as claimed in any preceding claim, which allows the transmission and reception of voice data via an Internet connection using the internal modem means.

52. A set-top box / home gateway apparatus as claimed in Claim 1, which incorporate a Global Positioning System (GPS) receiver means which is used in conjunction with the host processor to determine its global location and then select, tune to and program the various available broadcast channels from a range of satellite transponders and or terrestrial broadcast channels and or via a cable modem means.

53. A set-top box / home gateway apparatus as claimed in any preceding claim, which is implemented in a single equipment box means or enclosure means.

54. A set-top box / home gateway apparatus as claimed in any preceding claim, which is implemented in a more than one equipment box means or enclosure means.

55. A set-top box / home gateway apparatus as claimed in any preceding claim, which is implemented in a card frame means with insertably removable printed circuit board means.

56. A set-top box / home gateway apparatus substantially as described herein with reference to Figures 1-10 of the accompanying drawings.

Application No: GB 0125965.4
Claims searched: 1-3 & 15
Examiner: John Cullen
Date of search: 7 July 2002

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.T): H4P (PPA)

Int Cl (Ed.7): G06F 9/445; H04L 12/28, 12/66; H04N 5/00, 5/445

Other: Online: WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X, P	GB 2361849 A	(GRAEME ROY SMITH) See whole document, but particularly Abstract, Figs. 2 and 3, and lines 13-26 of p4.	1-2, 15
X, P	WO 02/06979 A2	(NDS) See whole document, but particularly Figs. 1-3 line 23 of p18 to line 4 of p19 and lines 27-30 of p19.	1-3, 15
X, P	WO 02/05560 A2	(GENERAL INSTRUMENT) See Figs. 2 and 4, and lines 3-10 of p9.	1-3, 15
X	WO 99/35753	(SONY) See Abstract and Figs. 3, 6, 17A and 17B.	1-2, 15
X	EP 0726675 A1	(ITALTEL) See whole document, but particularly Abstract and lines 5-16 of col. 1.	1-2, 15
X	US 6199137 B1	(LUCENT) See whole document, but particularly lines 39-51 of col. 2 and line 4 of col. 4.	1-3, 15
X	US 5973684	(BELL ATLANTIC) See whole document, but in particular lines 14-28 of col. 4.	1-3, 15

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Application No: GB 0125965.4
Claims searched: 1-3 & 15

Examiner: John Cullen
Date of search: 7 July 2002

Category	Identity of document and relevant passage		Relevant to claims
X	US 591639	(POWERTV) See whole document, but particularly Fig. 4 and line 6-14 of col. 1.	1-3, 15
X	US 5930515	(SCIENTIFIC-ATLANTA) See whole document. Note references to 'video' and 'satellite receivers'.	1-3, 15
X	US 566293	(BELL ATLANTIC) See Abstract, Fig. 1 and Fig. 7.	1-3, 15

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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